FRACTURES AND DISLOCATIONS
FOR PRACTITIONERS



FRACTURES AND DISLOCATIONS FOR PRACTITIONERS

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PREFACE TO THIRD EDITION

The increasing importance of traumatic surgery and new developments in the treatment of fractures call for another edition of this book As many of our surgeons have gone to war the physicians who remain must assume additional duties which include minor surgery and the care of fractures likewise the increase in accidents due to expansion of industry places an additional burden on them

The care of fractures is one of the most important duties of the general practitioner yet many men do not understand the fundamentals of the subject These injuries are the source of much anxiety to the medical profession the public expects a perfect result and unless the patient recovers completely there is a great deal of dissatisfaction Delay on account of a lack of understanding faulty judgment and neglect to apply common sense principles explain most of the unfortunate results

The author has emphasized the fundamentals of treatment which should be followed by every student and doctor New procedures have been simplified and sections on emergency treatment and fracture wounds which are vitally important at the present time have been prepared from the current war literature Considerable attention has been given to chemotherapy recent developments of which have practically revolutionized the treatment of traumatic wounds

The general practitioner should be familiar with the use of plaster of Paris and should know how to apply simple forms of traction In addition as the modern treatment of the long bones requires skeletal traction every doctor who does emergency work should be able to insert a Steinmann pin or a Kirschner wire Furthermore as compound fractures can occur anywhere and need immediate attention he should be able to perform a debridement operation without delay if an experienced surgeon is not available Although open reduction for some fractures has been explained in the text for obvious reasons such operations should be performed only by surgeons with experience

The many helpful suggestions of colleagues and the criticisms of reviewers have been appreciated and these were kept in mind as the present edition was written It is hoped that this revision will meet the need of a short complete textbook on the subject

EDWIN O GECKELER

Philadelphia Pa

PREFACE TO FIRST EDITION

The purpose of this book is to condense the subject of fractures and dislocations without the omission of important details Such a book is intended to fulfill the need for a complete yet simplified guide to the management of bone and joint injuries

On account of the increasing frequency and severity of highway accidents physicians should be well informed as to the management of injuries and since in these emergencies the early care to a great extent determines the end result, the immediate treatment should be in accordance with accepted present-day methods The value of competent attention in the prevention of disability is plainly demonstrated by statistics of industrial injuries

It is emphasized that elaborate equipment and complicated technic do not of themselves produce success as a satisfactory result for the greater part depends upon the intelligent use of general principles

Although much improvement has been accomplished by the use of certain standardized procedures for fractures the importance of individualization should be kept in mind and the form of treatment chosen only after a complete examination of the case

Only the one most practical method for a condition is advised, as in emergencies selection of the most appropriate treatment is confusing and time-consuming Providing the initial treatment has been adequate a very small proportion of fractures requires open reduction and for this reason description of operative technic has been limited to skeletal traction and subcutaneous leverage

The use of plaster of Paris is recommended and plaster technic is explained in detail as this is a form of immobilization which can be used universally

Since many persons fail to realize that careful follow up treatment is as important as the reduction of a fracture this part has likewise been given special attention

Such a practical consideration of the subject will be of distinct advantage to the undergraduate in supplementing the course of didactic lectures and it is hoped that the same arrangement will likewise be of value to physicians in general practice

I wish to thank Mr Maulsby Kimball for preparing the line drawings and in particular I wish to express my appreciation to the publishers Messrs William Wood and Company for their courtesy and help in the production of this book.

EDWIN O GECKELER

Philadelphia Pa , November 1937

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PART ONE FRACTURES

CHAPTER I

GENERAL CONSIDERATIONS

In order to understand the treatment of fractures it is necessary to approach the subject of bone injuries first from a broad point of view. One should remember always that the fracture itself is only a part of the injury. Other associated injuries as shock, hemorrhage and damage to viscerae may be even more serious. Before considering the essentials in diagnosis and management of the individual fracture certain preliminary definitions and explanations are required.

Definition of fracture. A fracture is a break in the continuity of bone.

Classification of fractures. The types of fracture are (1) simple (closed) (2) compound (open, potentially infected or infected) (3) pathological (spontaneous from bone disease).

Varieties of fracture. The varieties are incomplete, complete, fissure or linear, stellate, comminuted, impacted, compression, subperiosteal, green-stick and epiphyseal.

There are two main groups of fractures according to the nature of the trauma. (1) Indirect fractures caused by leverage, torsion or pulling force are usually linear. (2) Direct fractures, the result of blows or impacts, often are comminuted or compound.

According to age there are certain groups as birth fractures (infants), green stick fractures (children), epiphyseal fractures (adolescents). Fractures in the shafts of the long bones occur most often in adults. Fractures in the neck of the humerus and in the neck of the femur occur typically in later life.

Results of injuries causing fractures. When bone is broken it bleeds, the amount of hemorrhage varying according to the severity of the injury and according to the displacement of the fragments. Contusion and laceration of the surrounding skin, muscles and nerves also occur, with hemorrhage in and between the muscles. Usually there is ecchymosis which is extravasation of blood from the rupture of small superficial vessels and also extending from the bone. In most individuals this damage produces an absorption fever and moderate leucocytosis which subside after a few days. There is a varying amount of general shock depending upon the nature of the traumatism, the age and general condition of the person. For a short time after the injury the patient has comparatively little pain and the muscles are relaxed from the local shock. Later the part becomes acutely tender and there is decided muscle spasm

CHAPTER I

GENERAL CONSIDERATIONS

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Swelling which occurs almost immediately and increases during the first day gradually subsides after that

Definition of compound fracture A fracture is compound when an external wound communicates with it Compound fractures are caused (1) by severe direct force and by missiles which produce one or more wounds extending to the broken bone, (2) by indirect force, in which

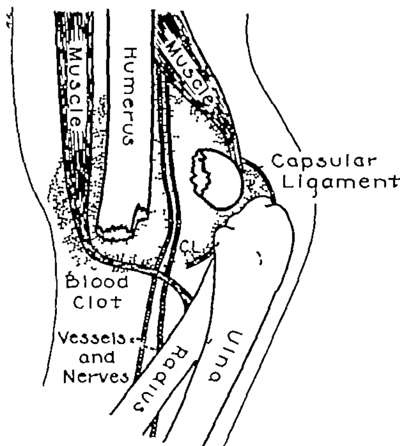


FIG 1 DIAGRAM OF A FRACTURE

Illustrating the injury to the soft structures which accompanies a displaced fracture near a joint Note the torn capsular ligaments and pressure by the fragments on vessels and nerves and hemorrhage in the fracture area.

leverage forces the fragments through the muscles and skin There usually is less infection in the latter form

Compound fractures are contaminated wounds in which there are foreign bodies and bacteria The important fact to bear in mind is that the defensive powers of the body can overcome a certain amount of bacteria present in compound fractures provided the wound has been immediately treated by debridement

Process of bone repair The repair which occurs in and around a

fracture is essentially the same repair which follows mechanical damage to other tissues except that the granulation tissue becomes ossified Blood from the torn vessels and bone substance forms a solid clot between and around the fragments within forty-eight hours As the clot solidifies new capillaries connective tissue cells and osteoblasts are formed in it, making the foundation of the bony patchwork Callus forms (*a*) in the medullary canal (*b*) between the periosteum and the bone, (*c*) between the bone fragments Bone healing occurs somewhat after the manner in which pieces of metal are welded together, the opposing ends first being softened before becoming fused This softening of the bone at

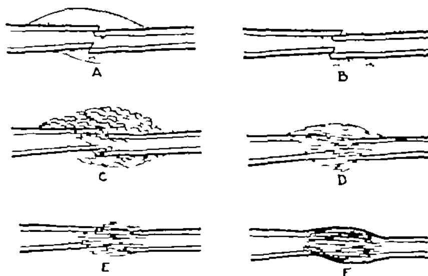


FIG 2 DIAGRAM ILLUSTRATING THE PROCESS OF BONE REPAIR

A hemorrhage at the site of fracture B, organized blood clot, with the beginning formation of connective tissue C procallus, a large spindle-shaped mass of connective tissue and osteoblasts The ends of the fragments are decalcified and undergoing chemical changes D the entire fracture area has become solidified E the callus has shrunken and has become laminated F the fragments are now firmly united by new bone tissue which is dense and hard

the site of fracture with the deposition of calcium and phosphorus salts is known as *autolysis* While bone absorption takes place calcium is deposited in the area of bone healing and this progressive change can be seen in a series of X ray films made after an ordinary fracture has occurred As the superficial swelling subsides, a spindle-shaped mass of spongy bone develops over and around the site of fracture This mass of new bone rounds off the irregular and prominent portions of the fragments and as it shrinks becomes converted into hard bone

In studying the chemistry of bone repair it has been found that the disintegration of bone and traumatized soft tissues at the site of fracture results in the formation of an enzyme called *phosphatase* This phos

phatase is present in a large amount at the site of fractures although only in their immediate vicinity Its action is thought to be the deposition of calcium and phosphorus salts by chemically transforming them from the calcium and the phosphorus present locally in the fragments and in the blood stream To function well this enzyme requires a certain hydrogen ion concentration which in turn depends upon the circulation to the part Thus delay in union is explained by impairment of the blood supply



FIG 3 SPECIMEN LONGITUDINAL SECTION OF FRACTURE SHOWING REPAIR

Note the rounding of the fragments and the thickness of the callus which completely covers the ends Such excessive callus formation is necessary on account of the extreme displacement

The metabolism of calcium and phosphorus and in turn the union of fractures to a great extent depend also upon the absorption of these elements from the gastro-intestinal tract The diet should contain an adequate amount of calcium and phosphorus also a sufficiency of vitamin D It is probable that a decreased acidity prevents the normal assimilation of these lime salts from the diet

As a general rule the younger the patient the more rapidly bone j

repaired Also the younger the individual is, the greater is the tendency for deformity to be overcome during and after union of the fracture

Delayed union implies that consolidation at the site of fracture has been slower than normal The quality of bone repair depends upon several factors *The blood supply to the affected part is important, for where* there is little circulation as in the neck of the femur union is necessarily slow and feeble When the muscles and periosteum with their vessels have been torn from the bone the diminished blood supply causes a delay in union The large area of bone surface in a severely comminuted fracture produces an extensive amount of callus, although this forms slowly The relative position of the fragments is significant, wide separation re-



FIG 4 SPECIMEN UNUNITED FRACTURE IN THE NECK OF THE FEMUR
The entire neck was absorbed on account of aseptic necrosis due to the interruption in the blood supply by the fracture

quiring a longer time for union than a linear fracture without displacement The security of immobilization also is important as the frequent movements due to inadequate splinting retard bone healing by tearing the new tissue and much movement may delay or even prevent union Age is an important factor as union in older persons proceeds more slowly than in earlier years The presence of infection is detrimental for this may produce absorption of bone with the formation of a mass of heavy scar tissue Loss of bone tissue for instance in gunshot wounds obviously causes a delay in union and in some instances results in non union

Non union pseudoarthrosis and *false joint* are synonymous and signify that bone salts have not been laid down in the area of fracture i e

there is no bony fusion of the fragments The main causes of non-union are (1) Insufficient or scanty blood supply to the part Examples are fractures in the neck of the femur and in the carpal scaphoid bone, and compound fractures with stripping of the periosteum from the bone and damage to the vessels (2) Extensive loss of bone substances in compound fractures creates a gap which in some instances is so wide that it cannot be connected by callus War wounds are examples of this (3) Interposition of soft structures may act as a barrier and actually prevent union Proof that this occurs has been found during operations upon fractures Repeated manipulations and inadequate immobilization are contributing

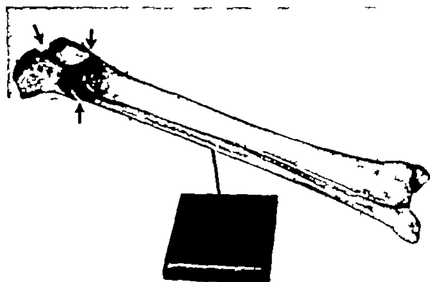


FIG 5 SPECIMEN PATHOLOGICAL FRACTURE OF THE TIBIA THROUGH A CYST
Spontaneous fracture occurred on account of the cavitation and shell-like thinness of the bone

factors Although bone repair is delayed by constitutional diseases even syphilis is not considered a cause of non union In many instances what is considered non union is only delayed union further immobilization being sufficient to produce firm union

Pathological fractures occur with little traumatism or spontaneously because of weakness of bone This weakness may be the result of (*a*) such constitutional conditions as rickets osteomalacia senile osteoporosis and syphilis (*b*) local conditions as osteitis osteomyelitis benign cysts and either primary or metastatic malignancy (*c*) neurotrophic changes The prognosis of these fractures depends upon the condition which produced such weakness in the bone They require general care and pro

longed immobilization Union occurs in a considerable proportion of the cases

Recurrent fractures occur in osteogenesis imperfecta (congenital fragility of bone), and with neurotrophic changes

Records of fracture cases. The history of accident cases should be accurate and it is important that the record be made without delay on account of claims and the possibility of severe complications or death If



FIG 6 PATHOLOGICAL FRACTURES OF THE FEMUR IN PAGET'S DISEASE

Weakness from fibrotic degeneration predisposes to fracture The lower fracture resulted from a slight twist as the patient was getting out of bed after the upper fragment had united Although such fractures unite readily union does not become as solid as in normal bones

possible that portion of the record concerning the immediate injury should be stated in the patient's own words As there are legal features to most accidents the exact time location and manner of occurrence should be noted also the names of persons who may have been responsible and of witnesses are necessary

The fracture record sheet sponsored by The American College of Surgeons is recommended for hospital cases The patient should be questioned as to whether or not there had been any previous trouble in the

affected part and any previous injuries or complaints and their treatment should be noted as these may influence the proposed treatment and the result Inaccurate records are often the source of much controversy loss of time and may be embarrassing in court Unless the record was made at the time of examination its use may be denied on the witness stand

Medical reports in industrial cases In injuries which occur during employment the employer or his insurance carrier must have accurate reports from the attending doctor, and these should be forwarded promptly Since the members of the claim department are laymen every-day language with a minimum of technical terms must be used In order to facilitate the details of investigation treatment, compensation and settlement practically all of the insurance companies require that a Standard Form for Surgeon s Report be filled out A paper written recently by Mr G Lester Marston, general claim manager of a leading insurance company contains so many valuable explanations and suggestions to the questions asked on this form that a large part of it is quoted here Acknowledgement is made to the author and to *The American Journal of Surgery* in which this article appeared Every physician who treats industrial injuries should be thoroughly familiar with its details

Standard Form for Surgeon's Report

First Section

The Patient 1 *Name of Injured Person* Write the name legibly in ink for this is the sole means of identifying the injured person and enables the carrier to connect promptly the report to the proper file

Age Too much cannot be said about the importance of giving the age for any layman knows that a broken ankle in a man of 20 and the same broken bone in a man of 70 may have vastly different consequences Furthermore it frequently happens that the age given by a patient to his physician is his true age whereas the age given to his employer may have been different

Sex Important oftentimes because the Christian name does not always indicate sex

2 *Address Number and Street* This is important for the purpose of identifying and locating the employee Frequently we find that the employee has not registered his latest address with his employer The address should be complete giving both the number and street and the name of the city town and state

3 *Name and Address of Employer* This is most important in identifying the employer of the injured man as records in most insurance companies are filed by the name of the employer

Second Section

The Accident 4 *Date of Accident Hour* The date of the accident and the definite hour of occurrence are of great importance as this information helps to determine whether the accident occurred during working hours and during the poli y

period The date of the accident and the hour of the accident are also important because many times the making of a claim alleging an accident is an afterthought on the part of the claimant and it becomes very important to check the statements given to the physician

Date Disability Began The date disability began is equally important with the date of the accident because in many instances there are delayed disabilities of perhaps days weeks or months following the alleged accident The date of disability is also important possibly in determining the causal relationship between the alleged accident and the condition found by the physician In such cases we have no date of disability or accident unless it is given by the physician

5 *State in Patient s Own Words Where and How Accident Occurred* It is always valuable and useful to put down in the first person just exactly what the patient said to the physician as to how the accident happened e g I slipped on some water and fell down landing on my back Such a statement contains the facts of what caused the fall and the part of the man s anatomy which was injured

Many times in compensation hearings the history given to the physician may be the pivotal point on which the decision of the referee or commissioner hinges It is of great importance to all claim examiners and medical or surgical advisers in determining the question as to whether the condition actually resulted from the alleged injury or not

Third Section

The Injury 6 *Give Accurate Description of Nature and Extent of Injury and State Your Objective Findings* When we come to this question we are impressed with the fact that this form of report appears to be a great record for a minor injury and a very small record for a large or serious injury In the latter case the information must be supplemented by a more complete report Yet it must be always borne in mind that this is a physician s story told to a layman and the avoidance of technical terms so far as possible is much to be desired However with a little practice and thought the description of the injury can be boiled down to a few words such as compound comminuted fracture of the right tibia in the mid third If there isn t room on the report use an extra sheet of paper for this is one of the most important items on the report Upon this description depends the evaluation of the case It also assists greatly in determining the question of whether the disability is being unduly prolonged The objective findings are of the utmost importance in determining the question of causal relationship between the alleged injury or accident and the condition found by the physician

7 *Will the Injury Result in (a) Permanent Defect (b) Facial or Head Disfigurement? If So What* Again a proper answer to these questions is of great importance in determining the value of the case not only from the standpoint of temporary total disability but from the standpoint of permanent impairment or disfigurement

8 *Is Accident Above Referred to the Only Cause of Patient s Condition? If Not State Contributing Causes* Important because some states do not recognize the aggravation by an injury of a previously existing systemic condition compensation in such states being payable only for a disability normally to be expected from that type of injury

9 *Is Patient Suffering from Any Disease of the Heart Lungs Brain Kidneys Blood Vascular System or Any Other Disabling Condition Not Due to This Accident? Give Particulars* The disability will be prolonged if the patient has an arteriosclerotic condition kidney trouble or a bad heart or any one of a number of diseases It

is therefore important that the attending physician the surgical director and the claim examiner have the fullest information so that they may coöperate together in shortening the period of disability

10 *Has Patient Any Physical Impairment Due to Previous Accident or Disease? Give Particulars* This is important too in that failure to give an accurate answer might involve the insurance carrier or employer in making a payment for a permanent impairment or amputation which had previously been paid for

11 *Has Normal Recovery Been Delayed for Any Reason? Give Particulars* This question is closely related to questions 8 and 9 and affords the physician an opportunity further to explain the reason if there is such for the delay in reaching normal recovery

Fourth Section

Treatment 12. *Date of Your First Treatment Who Engaged Your Services?* This is of extreme importance particularly in cases where treatment has been delayed and possibly an infection has gained the upper hand Oftentimes this date is important as it may indicate treatment prior to the actual date of this accident Again it might involve the question of which of two carriers there having been a change in carriers by the employer is responsible for the alleged injury and ensuing disability with consequential expense

The second part to this question— 'who engaged your services —is important in many states because of certain provisions of the law

13 *Describe Treatment Given by You* It is helpful in fact essential for the medical or surgical director to know exactly the kind of treatment rendered by the attending physician in order to determine whether it is proper treatment for the injury or condition whether it is the most up-to-date treatment or perhaps an outmoded treatment which has been found absolutely useless or almost useless in treatment of the condition present compared with modern treatment

Also if there was a wound was it sutured? Was it drained? Was it cleaned up? If there was a fracture was it reduced? Was it splinted? What was the nature or kind of splint? Was a satisfactory reduction obtained?

14 *Were X-rays Taken?* Such information is very important in certain types of injuries

By Whom? This is necessary information in order to determine whether or not an expert roentgenologist interpreted the plates To one inexpert in the reading of x ray plates a natural suture line in the skull might cause a mistaken belief that it was a fracture line It would be even more serious if there were an unrecognized fracture

When? Of course it is important that the date the x rays were taken should appear in the Surgeon s Report

15 *X Ray Diagnosis* We have already referred to the importance of this subject

16 *Was Patient Treated by Anyone Else? By Whom? When?* Physicians recognize the fact that quite often patients dissatisfied with a diagnosis travel from one doctor to another

In some states the law requires that the physician in filling out his report cover this question fully Sometimes an answer to this question would disclose the fact that the patient had been treated for a long time previously for something which he now claims results from a recent accident

17 *Was Patient Hospitalized? Name and Address of Hospital* The correct an

swer to this involves the securing of hospital records for ultimately there will be a hospital bill

18 *Date of Admission to Hospital? Date of Discharge?* These are important to the insurance carrier and employer in checking up bills received from the hospital

19 *Is Further Treatment Needed? For How Long?* This too is vitally important in determining whether specialized treatment which might be recommended by the physician would shorten or eliminate the disability It is very important that we know the period of further treatment if such is recommended

Fifth Section

Disability 20 *Patient* {*was* / *will be*} *Able to Resume Regular Work On?*

21 *Patient* {*was* / *will be*} *Able to Resume Light Work On?* Upon the answers to these questions depends the date on which compensation should cease They serve to satisfy the various boards or commissions that the insurance carrier or employer is warranted in stopping compensation on that date Question 20 relates to the fact that the employee was able to resume his regular work and 21 indicates that he was able to resume light work

22 *If Death Ensued Give Date* This question is obviously a very important one for record purposes

Examination of injured cases for fractures. Gentleness and careful handling of the patient cannot be over-emphasized

A General examination If the patient is extremely shocked it may be necessary to postpone a complete examination of the physical condition until later It is important to carefully differentiate unconsciousness, coma, intoxication and hysteria Complete disability may not indicate fracture conversely a fracture may exist even without deformity and disability Malingery always should be borne in mind and suspected when the complaints appear to be grossly out of proportion to the alleged injury In any severe injury it is of the utmost importance to consider the possibility of multiple fractures visceral damage and of local complications Failure to look for these may be disastrous

B Local examination Injury to bone is accompanied by bruising of the skin muscles and nerves distention from hemorrhage, and muscle spasm Additional pain and shock should be prevented by avoiding unnecessary movement of the accident case Often it is best to cut off a shoe and to rip clothing when undressing the patient First of all the injury must be carefully inspected If the patient is helpless or is unconscious the entire body should be examined In comparing the affected side with the unaffected side any change in the surface color and contour are noted Local swelling with the extravasation of blood under the skin are suggestive of fracture and when accompanied by deformity such a diagnosis is highly probable Voluntary movements of the part should be observed

Before palpating the affected area the patient is asked to indicate the location of his pain Unnecessary and purposeless handling should be avoided *It is important to examine the circulation of the limb feeling* the pulse and noting the condition of the superficial circulation Anesthesia or motor paralysis denote nerve injury from external violence or from internal pressure The physician should not attempt to elicit

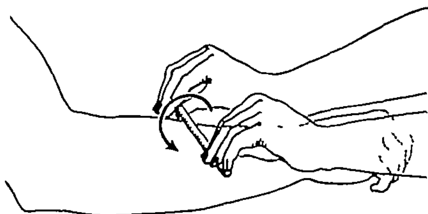


FIG 7 PENCIL ROLLING TEST
Wincing' point tenderness indicates a green-stick, incomplete or impacted fracture which otherwise might not be suspected

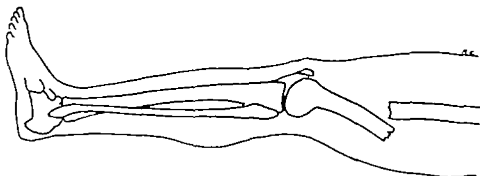


FIG 8 A COMMON SOURCE OF ERROR
Gross displacement may not be visible or palpable in a swollen or fleshy limb

crepitus as this gritting sensation conveyed to the examining fingers by moving the fragments causes further pain and the sharp edges may produce additional damage to muscles and blood vessels The muffled crepitus which is obtained by gently manipulating epiphyseal separations is characteristic and entirely different from the usual fracture crepitus Auscultatory percussion with a stethoscope and the pencil rolling test are helpful in doubtful cases

The signs of fracture are summarized as follows (1) loss of function (2) swelling and ecchymosis (3) wincing' localized tenderness

In addition there may be muscle spasm, abnormal mobility, shortening, deformity, crepitus and various complications

X-ray examination No matter how trivial the condition appears, every injury which causes persistent pain should have the benefit of X ray examination Although the physical signs may definitely indicate a fracture the exact condition of the bone can be visualized only by the X ray films This part of the examination is recognized as a routine procedure after an injury and if the physician neglects to secure an X ray examination before treating a case he subjects himself to the liability of a malpractice suit In rural communities however, where X ray apparatus is not available the law is more flexible



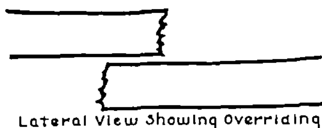


FIG 9 IMPORTANCE OF SEVERAL X RAY VIEWS
Demonstrating that examination in only one plane may be misleading Exposure should be made in at least two planes

In requesting X ray examination of limbs it is important to bear in mind that roentgen rays cannot penetrate steel splints, although wood aluminum and plaster of Paris offer little interference Adhesive plaster and metallic ointments also may interfere Exposures should be made in uniform directions at least in two planes at a right angle to each other It must be remembered that even if the fragments appear to be satisfactory in one plane there may be a decided displacement shown by examination in another plane Oblique films are valuable in certain locations and stereoscopic views are especially helpful in examining joints Films large enough to afford a view of the entire bone should be used as there may be multiple fractures at a considerable distance apart If the clinical course is suggestive of a fracture regardless of a negative X ray report other films exposed in a different plane may show the suspected condition In case of doubt as to whether or not epiphyseal separation or other osseous

injury exists it is wise to obtain identical films of the opposite uninjured side for comparison

General Directions for Guidance in X-ray Work of Fractures. (Note the following plan sponsored by the American College of Surgeons, has been modified for the author by Dr J Stauffer Lehman roentgenologist)

GENERAL DIRECTIONS FOR GUIDANCE OF X RAY WORK IN FRACTURES

Hand Two views Anteroposterior and oblique on one 10 x 12 film or two 8 x 10 films to include fingers and carpal bones If injury to carpal bones is suspected add a true lateral

Wrist Three views Posteroanterior oblique and lateral views on 10 x 12 film or three 8 x 10 films to include metacarpals and lower third of forearm

Forearm Two views Anteroposterior and lateral views on 10 x 12 films using care to see that both elbow and wrist are anteroposterior (hand in supination) and both elbow and wrist true lateral

Elbow Two views Anteroposterior and lateral on two 8 x 10 films. In case full extension of the arm cannot be obtained for the anteroposterior view make two anteroposterior exposures one with the posterior surface of the arm resting on the film and one with the extensor surface of the forearm resting on the film

Humerus Two views Anteroposterior and lateral on two 10 x 12 films.

Shoulder Girdle Two views Stereoscopic exposure on two 10 x 12 films to include head, neck and upper third of humerus and outer two-thirds of clavicle fore arm and hands in supination *Use Potter Bucky Diaphragm* If fracture of neck of humerus or dislocation of humerus is suspected or demonstrated add a lateral view made with the patient upright and the injured shoulder against the film with the uninjured arm raised to the side of the head

Chest for Ribs Two views Single 14 x 17 anteroposterior film Single 14 x 17 *film with the injured ribs in contact with the Bucky Diaphragm*

Skull Five views Stereoscopic of both sides of the skull on 10 x 12 films Single views on 10 x 12 films of the frontal bones of the occipital bone and a single view of the facial bones made in nose-chin (Water s) position Total of seven 10 x 12 films *All views on the Potter Bucky Diaphragm*

Facial Bones Two views on three 10 x 12 films Stereoscopic posterior anterior views made in nose-chin or Water's position Single lateral view with the affected side down *Use Potter Bucky Diaphragm*

Lower Jaw One stereoscopic view of the affected jaw upon 8 x 10 films the ray being directed obliquely upward

Cervical Spine Three views Stereoscopic anteroposterior on 10 x 12 film of whole cervical spine and stereoscopic anteroposterior on 8 x 10 film through open mouth to show atlas and axis *Use Potter Bucky Diaphragm* A single lateral on 10 x 12 film to be made *without* Bucky Diaphragm at six foot distance patient preferably in erect position with film against the shoulder and parallel to the spine

Dorsal Spine Two views Anterposterior and lateral on two 14 x 17 films *Use Potter Bucky Diaphragm*

Lumbar Spine and Sacro iliac Joints Two views Stereoscopic anteroposterior and single lateral on three 14 x 17 films *Use Potter Bucky Diaphragm*

Pelvis including both hips One view Stereoscopic on two 14 x 17 films To cover pelvis hips and upper portion of shaft of femur *Use Potter Bucky Diaphragm*

Femoral Neck Two views Stereoscopic anteroposterior 10 x 12 films of the hip Made on the Bucky Diaphragm when possible Single lateral 8 x 10 film using a curved cassette placed in the perineum and with ray directed at 45 degree angle or single lateral of pelvis with well thigh and knee flexed

Femur Two views Anteroposterior and lateral on two 14 x 17 films Preferably on Potter Bucky Diaphragm

Knee Two views Anteroposterior and lateral on two 10 x 12 films

Leg Two views Anteroposterior and lateral of entire tibia and fibula on 14 x 17 films Watch for fracture of upper third of fibula

Ankle Two views Anteroposterior and lateral on one 10 x 12 or two 8 x 10 films The anteroposterior view is to be made with the patient on his back the heel resting

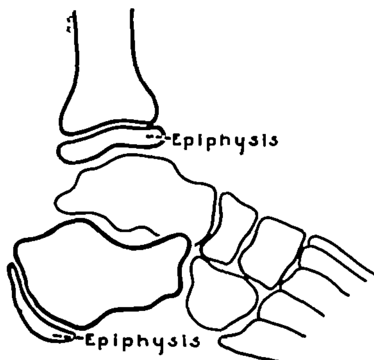


Fig 10 A Possible Error in Diagnosis

In examining X ray films of growing persons the epiphyseal line must not be mistaken for a fracture The normal epiphysis is smooth and is not displaced In doubtful cases the corresponding part of the opposite limb should be examined in the same attitude for comparison

on the film The lateral view is to be taken with the patient on his side the external malleolus resting on the film Never attempt to show an anteroposterior view of the ankle and foot on the same exposure

Foot Two views Anteroposterior and lateral on one 10 x 12 film or two 8 x 10 films Views should show tarsal and toe bones If injury to the metatarsals or phalanges is suspected add an oblique film of the foot

Os Calcis Special view When patient has fallen from a height and landed on his feet in addition to the anteroposterior and lateral views described above one additional view should be made of the os calcis This is best obtained with the patient lying on his back and 10 x 12 film under both heels and the tube so centered that the ray will pass through the os calcis at a 50-degree angle

Forms of fracture A fracture is said to be *incomplete* when the line or lines do not extend entirely across the bone A *linear* or *fissure* fracture is single while *stellate* indicates that there are multiple lines of fracture radiating from one point

In an *impacted* fracture which is located characteristically in the calcel lous portion of bone the fragments have been jammed together In a *compression* fracture which also is in the spongy portion of a bone the bone may be regarded as having been squashed The *green-stick* variety is seen only in children whose bones are soft and bend severely with minute cracks instead of snapping or break half way across *Subperiosteal* denotes that the break involves the bone without tearing its covering When an *epiphyseal* fracture occurs the epiphysis is displaced from the diaphysis or it may be actually fragmented *Avulsion fracture* and *sprain fracture* have the same meaning and imply that a small section of bone has been torn loose with its tendinous or ligamentous attachment

Every physician should learn to interpret X ray films, for by so doing he gains a more practical knowledge of fractures and can visualize their treatment

Progress during treatment and the extent of union are determined to a great extent by periodic roentgen examinations although the physician should consider the X rays only as a help and depend mainly upon his clinical judgment The time required for callus formation varies in differ ent fractures and in individuals Callus which has not solidified enough to withstand strain appears fluffy in the X ray film solid callus appears laminated the new bone being laid down parallel to the shaft of the bone In determining complete union the physician should be guided by firm manipulation as well as by the X ray films The appearance of super numerary bones in the hands and feet may be misleading as there is a wide individual variation and these must not be mistaken for minor fractures Although a normally ununited epiphysis does not resemble a fracture in case of injury the physician must depend upon clinical judgment in his decision as to whether or not an epiphyseal separation has occurred.

The fluoroscope in treatment of fractures. This is a valuable asset in the manipulation of certain fractures around joints however the X ray film is necessary to visualize finer details and also is necessary for a per manent record Although the oil immersion and shock proof machines protect the operator and patient from the electrical current they do not give protection from the roentgen rays A standard make of fluoroscope is necessary and should be operated only by a roentgenologist or techni cian Every apparatus should have an aluminum filter and the foot switch should be used intermittently for additional protection lead rubber gloves and apron should be worn The occasional use of a fluoroscope is

not dangerous as it has been proven that a two millimeter thickness of aluminum filter at a distance of 18 inches from the tube gives protection against an erythema dose to the fingers for 24 minutes. Frequent use of the fluoroscope should be avoided and no fracture should be manipulated under the fluoroscopic screen. The chief danger lies in the fact that the operator being occupied fails to realize the length of time he has been exposed to the X rays. On account of the danger of explosion ether and gaseous anesthesia for fractures in the fluoroscopic room should be avoided.

Prognosis of fractures. Before expressing an opinion the physician should make a general and local examination of the patient including an X ray examination of all parts suggestive of fracture. Severe shock, damage to viscerae multiple fractures and open wounds may be especially serious and the final result cannot be predicted. An apparently trivial injury may cause a decided disability. Allowance must be made for individual variations and delays and it should be understood that any estimate is based upon past experience with similar cases. Finally other factors as the age of the patient his general condition the type of fracture and its location the position of the fragments and the follow-up care must be considered in the prognosis.

Medicolegal aspects of fractures. Every physician ought to be covered by medical protective insurance. Neglect to order X ray examination and failure to diagnose a fracture are common reasons for damage suits both of which can be prevented if the physician insists upon films being made routinely and as often as he requires them regardless of the patient's wishes. Such a routine does not apply to isolated communities where X ray equipment is not available. The doctor should keep at least a copy of the films in his possession as these records are important in event of legal proceedings. X ray negatives are the property and part of the records of the hospital or the physician who made the X ray examination. A great number of malpractice suits are based on the desire of the patient to avoid payment of the bill with no complaints until the doctor has instituted proceedings to collect his fee. Judgment should not be influenced by the opinions or criticism of the patient or his family, if he is dissatisfied or if the physician is in doubt as to treatment a consultation should be procured. Permission should be obtained from one of the parents before administering a general anesthetic to a minor. Other important points to be remembered are to avoid giving advice or information by telephone and never to pass judgment on the results of a case treated by another physician. Finally it also should be remembered that the law requires a medical practitioner to manage a case according to the accepted methods which are employed by other physicians in his community.

Complications of fractures. The most common complications are circu

latory disturbance, fat embolism, infection deformity non-union disturbance of bone growth paralysis, and limitation of motion

Circulatory disturbance (*a*) Edema is due to damage of the blood vessels and lymphatics also may be the result of pressure by displacement or angulation of the fragments The position of immobilization tight dressings and the improper padding of splints also may cause a disturbance of the circulation (*b*) Gangrene may follow injury to the main artery of the limb from complete division or penetration by a bone fragment may be due to contusion of the vessel wall producing thrombosis and also embolism at the bifurcation of an artery The following signs indicate severe

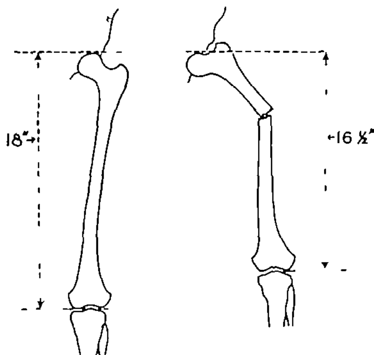


FIG 11 ILLUSTRATING SHORTENING FROM ANGULATION WITHOUT OVERLAPPING

disturbance the pressure of pulsation above but impairment or loss of it below the level of the injury cyanosis and stone coldness of the limb distal to this level the formation of large blebs pain and tenderness exactly over the main vessel at the area of injury (*c*) Ischemic contracture (Volkmann s paralysis) is believed to be due to an acute venous obstruction caused by the pressure of a large blood clot with the resulting rapid necrosis of muscle fibers which is followed by the formation of extensive fibrous tissue and consequent contractures Although this condition occurs most commonly after elbow fractures in children it is seen also in the lower limb In some instances tight bandaging or hyperflexion at the elbow appears to have been a contributing factor The diagnosis is made by the severe

pain which appears early, cyanosis and coldness of the hand and loss of power in the fingers

Fat embolism This complication may occur after any fracture of a medullated bone, and is most frequently observed after fractures of the femur Petechial hemorrhage and the presence of fat globules in the urine or sputum are strongly suggestive signs Fat embolism chiefly affects the lungs or the brain When the lungs are involved there are signs of pulmonary edema, with rapid respiration and bloody frothy expectoration The signs in the cerebral form are delirium restlessness, and often coma which precedes death



FIG 12. VOLKMANN'S ISCHEMIC CONTRACTURE

This crippling complication occasionally follows fractures and may be due to tight dressings Occasionally ischemic contracture occurs in the lower limb (Courtesy of Dr Tom Outland)

Infection This is common in compound fractures Even in a closed fracture the hematoma may become infected in some instances on account of dental and tonsillar disease

Deformity Malunion from angulation is almost always preventible by complete reduction and adequate immobilization or traction The part should be inspected regularly and periodic X ray examination is useful in checking the progress In cases wearing plaster of Paris or other dressings which are not readily removed angulation deformity may be overlooked unless X ray examinations are made The angulation in a green-stick fracture usually will recur unless the bone has been intentionally broken during manipulation In most instances the shortening in a long bone which is due to over riding of the fragments can be overcome by prompt

manipulation or by adequate traction In order to produce the best results traction must be applied early, before muscle spasm has become muscular contracture. Often skeletal traction is effective when adhesive traction fails to overcome the overlapping In children a moderate amount of shortening is not serious as this is compensated for during subsequent years of growth In adults however even one-half inch shortening of the thigh or leg usually causes a permanent limp

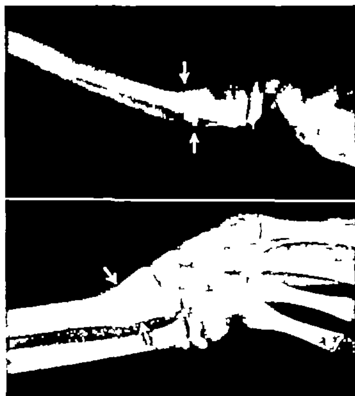


FIG 13 FRACTURE OF RADIUS FOLLOWED BY GROWTH DISTURBANCE
The deformity is a result of injury to the epiphysis with subsequent shortening of the bone

Disturbance of bone growth A large proportion of epiphyseal fractures or separations cause disturbance of growth on account of premature ossification at the epiphyseal line and are followed by shortening and deformity Perfect reposition does not insure normal growth the cause of this disturbance being damage to the cartilage plate

Most deformities in the long bones resulting from fractures in childhood tend to become corrected during subsequent growth The contour alinement and length of the limb usually are restored within a few years This is especially true in young children Angulation deformity in a united fracture tends to become a generalized curve Over-growth occasionally

occurs after fractures of the long bones in children, and is believed to be due to periosteal stimulation

Paralysis The occurrence of peripheral nerve injury with fractures is not uncommon This complication is found most often with fractures in the region of joints as the elbow and knee also with bullet and shell wounds In relative frequency the common peroneal radial and ulnar nerves are most often involved A nerve may be injured primarily by contusion laceration or pressure at the time of the accident Secondary nerve damage may occur from forceful manipulation and the pressure of



FIG 14 MALUNITED FRACTURES OF THE LEG

This result is an example of poor initial treatment and inadequate follow up care The internal fixation was unnecessary and unsatisfactory The deformity should have been prevented by skeletal fraction followed by application of plaster

splints and dressings A nerve also may be involved secondarily by the constricting effect of fibrous tissue and callus formation An example of late involvement is the delayed ulnar paralysis which sometimes appears many years after fracture of the external condyle of the humerus caused by the tension on the nerve by the deformity

Limitation of motion Traumatism or infection incidental to fracture may cause inflammation in joints and tendon sheaths with painful motion or restriction of motion The formation of excess callus by a fracture extending into the surface of a joint may cause limitation of motion and in many instances displaced fragments projecting into a joint produce bone-block The degenerative arthritis which is common in middle life and

later years frequently is aggravated by injury and subsequent immobilization with resulting chronic pain and limited motion. Fibrous ankylosis *from contractures and adhesions of the soft structures after prolonged* immobilization and edema is common, especially in small joints as of the hand and foot The disabling fibrosis after infections of the hand is well known Infected compound fractures in the region of joints often are followed by bony ankylosis Many comminuted joint fractures are followed by limitation of motion and even bony ankylosis

Post traumatic osteoporosis or acute bone atrophy is a condition characterized by a decided decalcification and mottling which appears in the



Fig 15 Deformity from Loss of the Distal Epiphysis
This condition followed a compound fracture The distortion was caused by interference *of growth in the tibia the unaffected fibula having continued to grow* normally

X-ray films soon after injury This injury may have been only trifling as a sprain or minor fracture of the ankle It is believed that the condition is due to a trophoneurotic disturbance which results in a localized hyperemia and consequent cyanosis of the hand or foot Pain is increased on motions and there is a decided tendency to chronicity and ankylosis of the affected joints In many instances this condition can be cured by early and persistent function with the support of unpadded plaster splints walking casts and Unna s paste dressings It has been shown recently that resistant cases can be cured by the operation of periarterial sympathectomy

Hospital organization. Increased industrial activity and heavier motor traffic throughout the country call for better hospital facilities for the management of fractures

In every large hospital a separate fracture service should be maintained in order to improve and carry on the proper treatment. The members of this service should continue on duty throughout the year or if there is a rotating service it should not change frequently. Organization and team work are essential. Regular conferences should be held for the purpose of discussing current cases and a routine follow-up system should be maintained. The American College of Surgeons has published standard fracture requirements for hospitals and the official Fracture Record sheets which it sponsors are available at a small cost.



FIG. 16. X-RAY FILM OF ANKLE IN PRECEDING ILLUSTRATION
Note the extreme tilting of the astragalus and disruption of the ankle mortise, the articular surface of the tibia being absent

It has been shown that two-thirds of all major accidents in civil practice occur in rural districts; therefore not only large city hospitals but all small hospitals should have a fracture organization. In small institutions at least two staff members should be responsible for accident cases, one to help the other and to substitute during the other's absence.

It is not necessary to have elaborate or expensive equipment. The American College of Surgeons requires the following or their equivalents: Murray-Jones arm splints, Thomas or Keller Blake lower limb splints with Pearson knee attachment, Hodgen splints, Cabot leg splints, an assortment of wooden splints and plaster of Paris bandages; also equipment should be kept ready for suspension and traction of major fractures. The plaster of

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Paris bandages always should be made by the same nurse or orderly, who understands how to make them properly X ray facilities should be available for 24 hours every day in the year A table of instruments for emergency operations as insertion of skeletal traction and debridement should be in readiness the instruments being sterilized daily

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CHAPTER II

EMERGENCY TREATMENT

The principals of emergency treatment apply to every injured person at any time and place during either peace or war The four principals to be observed are

1 Prevention and treatment of shock
2 Arrest of hemorrhage and proper dressing of the wound
3 Immediate splinting
4 Careful transportation

Prevention and treatment of shock. Shock is a condition in which there is a decided depression of all the functions of the body All injuries are followed by shock which varies in amount according to the severity of the accident the amount of hemorrhage the extent of tissue damage and the multiplicity of injuries There may be contributing factors as fear dehydration exposure to cold and delay between the time of injury and treatment Primary or light shock is the state of collapse which resembles fainting and responds in a short time to simple forms of treatment After severe injuries especially war injuries as compound fractures a state of secondary shock appears This is characterized by paleness listnessness subnormal temperature weak and rapid pulse and lowered blood pressure with collapsed veins Other signs are irregular breathing sweating, nausea and vomiting and decided thirst These evidences of wound shock may appear immediately or may not be noticed until several hours later however there usually are prodromal signs which precede the others It is important to recognize the early indications of shock as delay may be fatal Trueta who treated a large number of war injuries is convinced that secondary shock is due to the absorption of disintegrating tissues When thorough debridement operations were performed within two hours this true shock did not occur

Authorities do not agree as to the exact nature of traumatic shock however in most instances it is recognized that there is vasoconstriction with a decrease of the blood volume Usually it is impossible to prevent this condition but its severity can be reduced Treatment of shock should be commenced before the clinical signs appear The prodromal paleness and listnessness in the presence of injury call for prompt treatment The appearance of the wound and lack of severe pain are apt to be misleading In the treatment of shock bear in mind the following points

1 Give primary attention to the patient and not to the wound
2 Avoid unnecessary movement of the patient or of the injured part

3 Administer morphine in sufficient quantities, usually from ¼ grain to ½ grain
4 Keep the patient in a warm place, and apply external heat to his body
5 Arrest hemorrhage, using a tourniquet if necessary
6 Remove wet clothing by cutting it off in order to avoid unnecessary movements
7 Give warm drinks such as coffee tea or cocoa if the patient is able to retain them
8 Immobilize the injured part
9 Do not move the patient until the above measures have been carried out
10 Give fluids preferably blood intravenously, if whole blood is not available immediately give blood plasma or serum.
11 Avoid extreme heat on account of dehydration from excessive sweating
12 Do not operate until the blood volume has been restored and dehydration has been relieved

Transportation. No injured person should be moved until his wound has been dressed and the fracture has been immobilized securely Even then it may be necessary to wait for a short time before moving him on account of the gravity of his general condition from shock Calmness and the avoidance of unnecessary haste are important and rough and unnecessary handling should be avoided

Arrest of hemorrhage and wound dressings. Prevention of further loss of blood and protection of the open wound are important factors in the care of the severely injured Severe hemorrhage may require the use of a tourniquet to save the patient's life if a regulation tourniquet is not available a belt necktie handkerchief or towel will suffice This should encircle the limb *once being applied proximal to the injury A stick is laid* underneath the loop being twisted only sufficiently to stop the flow of blood The constriction should be loosened momentarily every 15 minutes and should be removed as soon as possible The routine application of a tourniquet is condemned as statistics show that 80 per cent of limbs to which tourniquets have been applied for as long as three hours have come to amputation A prominent author states more lives have been lost in war from improper use of the tourniquet than are saved by its proper use The wound should not be washed because of resulting contamination.

Immediate splinting Do not manipulate the injured part to determine whether or not a fracture exists if there is any doubt treat it as for a fracture It is important to prevent further damage and complications by *immediate splinting* It should be remembered that the injury in a fracture case is not limited to the bone Careless handling attempts to use

the injured part or injudicious attempts at correcting the deformity increase pain and may cause further damage to muscles vessels, nerves, and also may displace the fragments In compound fractures every movement increases the element of infection

The dictum 'splint em where they lie' has saved much pain, further injury and shock The patient should not be moved or transported before adequate splinting has been applied The position of the limb must not be changed until the splint is ready for application For fractures of long bones, emergency traction is advisable, and in applying this traction the manual pull on the limb should not be released until the splint is in place

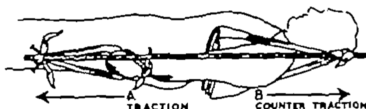


FIG 17 EMERGENCY TRACTION FOR FRACTURES OF THE HUMERUS
A pole with a nail is used for the splint with a folded towel as padding in the axilla for countertraction and a cravat is used for traction at the wrist (After American Red Cross First Aid Text Book)



FIG 18 MURRAY-JONES TRACTION SPLINT
Used for fractures in the shaft of the humerus Hinges on the ring facilitate application of the splint

Injuries of the spine Every person whose back has been injured who has been in a serious collision or has fallen a considerable distance, should be regarded temporarily as having a fracture of the spine and should be treated accordingly When the neck is involved the patient must lie on his back and no movements should be permitted He must not be lifted or transported until a long broad board or stretcher has been placed under his entire body, with a folded coat or pillow behind his neck When the back is injured the patient should be kept lying face downward In preparing him for transportation he first should be turned on his side while a stretcher or broad board is placed beside him, then there will be no further damage to the back as he is turned over

Injuries of the face For fractures of the jaws the chin should be raised to bring the lower teeth against the upper teeth the jaw being bound with a cravat bandage passing under the chin and tied over the top of the head

Upper extremity In splinting the humerus and forearm various mate-

rials at hand often must be utilized in emergencies, if standard equipment is not available Whatever form of splinting is used should be sufficiently broad and long enough to extend beyond the joint above and below the broken bone For the upper arm a well padded external lateral board splint is applied with the elbow held at a right angle and combined with a sling A folded newspaper may be used or the arm may be bandaged snugly to the chest after a sling has been applied

When the elbow is involved it should be bandaged to the body if it is found flexed, if it is extended it is best to leave it in this attitude and apply a straight splint



Fig 10 Emergency Splinting of Forearm with a Newspaper

An improvised fixed traction splint for the humerus can be applied when a long board or stick is available This splint should extend 12 inches above the shoulder and 12 inches below the hand and a notch should be cut in each end of it A cravat or loop of bandage is applied over plenty of padding in the form of a pillow or folded shirt placed in the axilla and then the cravat or bandage is fastened to the upper notch of the splint for countertraction Next a cravat or well padded bandage is applied to the wrist and traction on the limb is made as the ends of the cravat or bandage are fastened to the notch in the lower end of the stick Finally a Spanish windlass may be added for additional traction although in many cases this should be avoided on account of the tendency to over pull

The ideal emergency traction device is the standard Murray-Jones splint which is a hinged form of the Thomas splint This splint is available at highway first-aid stations is in ambulances and patrol cars and is kept in the emergency rooms of industrial plants and hospitals, also is used routinely in military service While the patient lies on his back the hand is grasped and with moderate straight traction is pulled through the ring of the splint the padded ring fitting into the axilla A well padded cravat or bandage is applied to the wrist and hand and then the two ends are tied to the notch at the end of the splint The entire limb is covered with a broad bandage and the Spanish windlass" may be added to increase the pull if necessary although over pull should be avoided (For further details see American Red Cross First Aid Text Book) If it is important

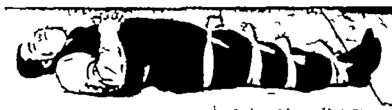


FIG 20 EMERGENCY TREATMENT OF FRACTURES OF THE THIGH
Both lower extremities are bound together when a Thomas splint is not available

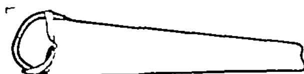


FIG 21 KELLER BLAKE MODIFICATION OF THOMAS SPLINT
The half ring permits application of emergency traction on the lower limb with a minimum amount of movements

to inspect the limb frequently and if the swelling increases the bandage or traction must be loosened

Lower extremity Boards or fence-rails may be used if standard splints are not available Any form of splinting is better than nothing and even bandaging the injured lower limb to its fellow is helpful in limiting movements of the fragments The splint should be long enough to extend to the upper portion of the chest and beyond the heel Sufficient padding must be applied before bandaging and it may be necessary to loosen the bandages later if swelling increases

An improvised traction splint in the form of a board or a pole should be long enough to extend 12 inches above the hip and 12 inches below the heel Both ends should be notched or a nail may be driven into the ends A loop of bandage or cravat is placed over a pad in the groin and then is fastened through the notch in the upper end of the splint The foot next

is grasped firmly and as steady traction is made a loop of bandage or a cravat is fastened to the ankle sufficient padding being added The ends of the bandage or cravat then are tied to the notch in the lower end of the splint while the steady traction is continued Finally a "Spanish windlass is added a short stick being inserted beneath the traction loops and twisted to increase the traction Padding should be used over the fractures and

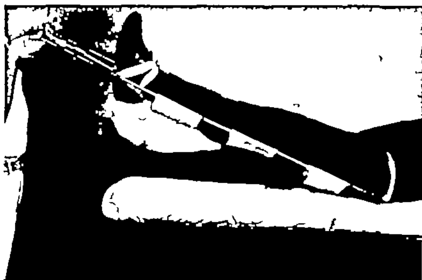


FIG 22. THOMAS SPLINT WITH 'SPANISH WINDLASS
This provides temporary immobilization and traction for fractures of the femur

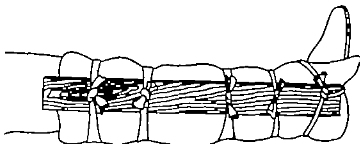


FIG 23 EMERGENCY SPLINT FOR FRACTURES OF THE LEG
The pillow is reenforced on both sides with wooden splints

over bony prominences and finally a wide bandage should be applied over the entire limb and splint It may be necessary to loosen the traction if there is interference with circulation on account of increased swelling

The ideal and standard emergency traction device for fractures of the thigh and leg is the Thomas splint During World War I the British Army reduced its mortality rate from compound fractures of the femur from 50 per cent to 15 per cent by the immediate application of Thomas splints by

stretcher bearers The Keller Blake splint is a modification of the Thomas splint having a half ring with tape and buckle instead of the entire ring During the application of a Thomas splint the patient lies on his back, and his clothing and shoe are not removed While an assistant grasps the ankle and exerts firm and steady traction the ring of the splint is drawn up over the limb until it fits snugly against the groin and buttock A traction loop of bandage or a cravat is applied to the ankle over the shoe A cravat hitch is made by placing the center of a triangular bandage under the center of the foot like a stirrup the two ends are crossed over the instep, then passed behind and around the ankle above the heel and finally are passed forward under the first loops The ends of this traction hitch then are tied to the notches in the end of the splint and a piece of wood is inserted between them for additional pull by twisting Prolonged use of this 'Spanish windlass' may cause pressure sloughs over the ankle and foot Finally a broad bandage is applied over the entire limb and splint and the end of the splint is elevated over a solid object or is suspended with a rope The circulation should be watched and if swelling increases the bandage and traction must be loosened (For further details see American Red Cross First Aid Text Book.)

The application of a Thomas splint for emergency and subsequent treatment of fractures in the lower limb may be simplified and improved by the use of a Steinmann pin and Caldwell lugs Under strict aseptic technic a stout pin is inserted through the heel and then is fastened to each side of a Thomas splint with the Caldwell lugs The arrangement maintains a constant pull without permitting rotation of the lower fragment This form of traction recently has been adopted by some portions of the British army

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CHAPTER III

FRACTURE WOUNDS

In civil practice most fractures are closed In war a large number are combined with open wounds Compound fractures are increasing on account of heavy motor traffic and in war they comprise about 60 per cent of all fractures These injuries are caused (1) by severe direct force and (2) by indirect force

1 *Severe direct force* In this form the soft tissues have been lacerated by the penetration of one or more foreign bodies Such compound fractures occur especially in wartime, not only in combat but also among the *civilian population These wounds are caused by bullets bomb fragments* pieces of wood, stone and glass They are more serious than most of those which occur in times of peace The fragments are decidedly comminuted and there is severe soft tissue damage from shell and bomb fragments Extreme damage by shells and bombs is common in the present war Crushing injuries as occur in industry and transportation also cause severe compound fractures Although the skin wound may be small the external appearance is not a reliable indication of the severity of the condition. A majority of compound fractures are further contaminated by bits of clothing and dirt and unless the injured limb is splinted the contamination will be spread by every movement Although the application of a traction splint may retract the fragments and thereby further contaminate the wound such first aid prevents additional soft tissue damage hemorrhage and shock, and is indicated for most cases

2 *Indirect force* causes the other main form of compound fracture, in which the skin is pierced by the sharp fragments of bone as they protrude In this form there is less soft tissue damage and much less contamination In many instances when only a puncture wound is found over a fracture without deformity the skin already may have been severely damaged by a sharp fragment of bone which later was retracted One should not be misled by the seeming unimportance of such small skin wounds but should treat such cases as carefully as those with large wounds

When there is a wound in the skin any organism may be introduced Compound fractures occur most frequently in the lower limbs, on the highways and in war Bacteria especially staphylococci and streptococci are carried from the skin surface into the depth of the wound Foreign bodies usually are greatly contaminated and clothing teems with bacteria Tetanus and gas-bacillus infection may occur in any wound but are especially

common with compound fractures in war injuries, on account of the extensive damage to muscle tissue

Simple or closed, fractures may become secondarily open or compounded if the skin has been so severely bruised by direct injury that it sloughs



Fig 24 Fresh Compound Fracture
The bone is protruding through the wound and there is extensive bleeding



Fig 25. Gas Gangrene
This condition followed a minor compound fracture at the ankle No debridement operation had been performed Note the distension of the tissues the blebs and massive gangrene The patient died six days after the injury despite amputation

Ineffective splinting may permit so much pressure of sharp fragments that they penetrate the skin delirious cases may be so uncontrollable that their movements cause the fragments to penetrate the skin, regardless of splinting.

The common complications and results of compound fractures are

1 Shock This varies *according to many factors including the condition* of the patient the location and nature of the injury early care of the patient and of the injured part and subsequent treatment

2 Gross infection of the wound Usually proper attention to the wound within six hours prevents gross infection, converting a contaminated wound to a relatively clean wound When gross infection occurs on account of extreme damage or lack of a proper operation there may be loss of limb or of life and at least there will be a long period of convalescence If gas infection or tetanus develops there is a high mortality During World War I 54 per cent of the casualties in the United States army were due to wounds of the soft structures and 29 per cent were due to compound fractures of the limbs

3 General sepsis Severe local infection often results in toxemia which may be fatal

4 Delayed union Important factors producing delayed union are extensive damage to soft structures ineffective immobilization comminution of fragments and loss of bone substance If the fragments are not reduced and infection is present the final result often is non union

General Treatment. *Shock* Every severely wounded person is shocked especially if there is accompanying soft tissue damage and hemorrhage such as occurs with compound fractures Shock should be anticipated and prevented as much as possible When the patient is severely shocked the general treatment must have precedence over local treatment Unnecessary handling should be avoided morphine should be given in sufficient quantities the patient should be kept warm and wet clothing should be removed Further movements of the limb can be avoided by cutting the clothing The injured part should be immobilized traction splints being used when possible Transfusions should be given if whole *blood is not available immediately serum or plasma are advisable* The patient should not be moved until the systolic blood pressure is at least 100 mm

Immediate treatment of the wound. The wound should be covered immediately with a pad of sterilized gauze but should not be packed because of introducing further infection A tourniquet should be applied if bleeding is profuse The routine practice of immediately placing sulfanilamide powder in the wound is of great help in reducing the growth of bacteria and prolongs the period in which debridement can be performed safely From 5 grams to 20 grams of the sterilized powder should be spread through the wound the amount depending upon the size of the injury It may be shaken in or when the wound is not wide open the edges should be retracted with sterilized instruments so that it can be spread through the

tissues with a gloved finger or curette In civil practice, when the patient's condition is grave on account of severe shock or multiple injuries, the injured part may be refrigerated, thus, by the application of ice or of a refrigerating coil the growth of bacteria is prevented and operation may be safely deferred

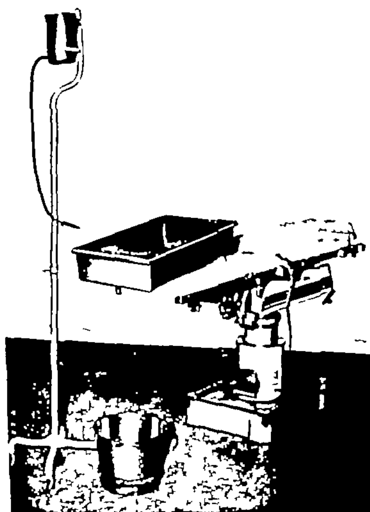


FIG 26 EQUIPMENT FOR DEBRIDEMENT OF COMPOUND FRACTURES
Tray covered with ½ inch wire mesh and provided with pipe drain Irrigating stand with can tube and nozzle (See next illustration)

Operation for compound fractures. Compound fractures are urgent emergencies The essentials of treatment are (1) to clean the wound immediately (2) to reduce the fragments (3) to immobilize the fracture The shorter the time between injury and operation the better If operated upon properly and during the first few hours contaminated wounds will be converted into clean wound but in most instances after six hours

infection has spread to such an extent that operation may be of comparatively little help *Debridement* literally means enlargement of the wound and this only *Wound excision* means removing a portion or all of the structures involved in the wound track this is a more radical form of operation which often is unnecessary or it may be impossible to carry it out completely Wound excision should be done only within the first six hours before the contaminated wound has become infected, the operation

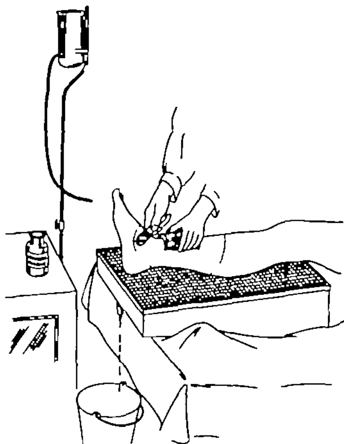


FIG 27 DEBRIDEMENT OF COMPOUND FRACTURES

The surrounding skin is scrubbed thoroughly with soap and water or benzine may be used when water is not available The dressing, which was applied immediately after the injury is not disturbed. (See next illustration)

of debridement or enlarging the wound may be performed even after six hours If possible an X ray examination should be made before the operation not only to show the nature of the fracture but also to demonstrate the presence or absence of foreign bodies High velocity wounds from machine guns and rifles ordinarily do not need debridement as these are relatively clean with little tissue damage

Preparation for operation. The wound should not be exposed or further

contaminated by repeatedly changing the dressing The use of a tourniquet during the operation is advisable only when there is severe hemorrhage When possible, splinting or traction should be continued during the entire procedure The pad of gauze placed over the wound should be held in place firmly while a large surrounding area of skin is shaved and gently but thoroughly scrubbed with soap and water The wound then is uncovered, the skin is painted with tincture of iodine and then draped with sterile towels Two tables of instruments and dressings should be set up, the first table should be used for the preliminary part of the operation and the second table for the remainder of the procedure If time and circumstances do not permit cleansing the skin with soap and water benzine is

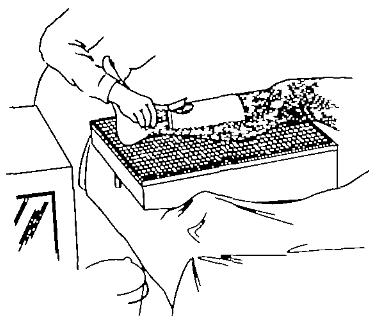


FIG 28 DEBRIDEMENT OF COMPOUND FRACTURES
The skin around the wound next is shaved (See next illustration)

advised The injured part should be immobilized until the patient is anesthetized otherwise movements increase shock and struggling adds to the tissue damage

Operation. The edges of the entire skin wound are excised with a scalpel and the wound is enlarged by making a long incision in the skin and deep fascia to permit complete exposure without forcible retraction During the entire procedure no gauze mop should be re-inserted because of spreading infection Rough mopping should be avoided The scalpel, scissors and forceps should be wiped off continuously for the same reason The walls of the wound should be picked up with tooth forceps and all muscle tissue which does not bleed on section and does *not contract* when pinched should be excised The ends of completely divided muscle must

be found and excised even if further enlargement of the wound is necessary *Complete hemostasis is important all blood clots should be removed*, and bleeding vessels ligated with fine catgut Plugged vessels may bleed later unless tied Cut tendons should be brought together with single silk sutures Small fragments of bone which are completely detached should be removed and the dirty surfaces of the main fragments should be trimmed off with ronguer forceps, foreign bodies also are removed at this time When there is a through and through wound twisted gauze should be drawn back and forth for cleansing the tract Then the interior of the wound is thoroughly irrigated with at least four quarts of warm normal saline solution for which purpose a douche can with hose and nozzle are

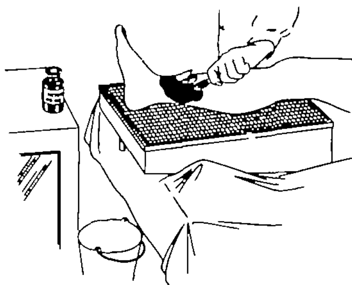


FIG 20 DEBRIDEMENT OF COMPOUND FRACTURES
The skin then is painted with tincture of iodine (See next illustration)

useful All of those engaged in the operation then should change their gowns and gloves and the second instrument table is used for the remainder of the procedure Next sterilized sulfanilamide powder is spread through the wound with a gloved finger from 5 grams to 20 grams being used according to the size and contamination of the wound

The question of whether or not to use internal fixation depends upon the condition of the patient the skill of the operation and the armamentarium available Certainly internal fixation is definitely indicated in many cases but so far it has not been practical in actual warfare Plates and screws made of Vitallium or stainless steel may be the only means of maintaining reduction of the fragments their use limits wound infection and by secure immobilization they aid fracture repair

The only safe practice is to leave every compound *fracture wound open*

if the wound is sutured and infection develops the result may be disastrous In war surgery it is customary to leave all compound wounds wide open, so that they heal by granulation In civilian practice exceptions may be made in relatively clean wounds which are operated upon early, but no wound should be sutured under tension

Treatment of compound joint fractures Wounds of joints even as small as stab and bullet wounds may be as serious as much larger wounds elsewhere The debridement incision should be large enough to permit thorough exposure When the wound is jagged and very soiled an elliptical incision should be made around it The wound edges should be excised beginning with the skin and extending to the synovial membrane All subfascial hematomas should be removed and if fragments of bone are completely detached they should be taken out Fragments which are

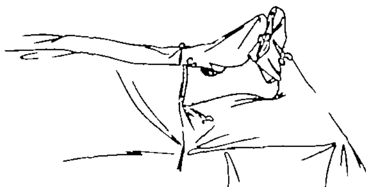


Fig 30 Debridement of Compound Fractures
The affected part is draped as carefully as for other operations (See next illustration)

attached to periosteum or muscle are viable and should not be removed unless they are displaced and cannot be reduced Internal fixation although satisfactory for selected civilian injuries is not advocated in war cases If facilities permit the entire wound next is irrigated from within outward using quarts of sterile normal saline solution The synovial membrane then should be dried and sterilized sulfanilamide powder dusted into the entire wound The synovial membrane should be sutured unless more than 24 hours have elapsed since the injury In war surgery the remainder of the wound must be left wide open with plain gauze or vaseline gauze placed between the walls and extending down to the synovial membrane In civil practice some authorities advise closure of the entire wound providing the operation is performed without delay however in closed wounds there always is a possibility of severe infection which might be disastrous

Finally the joint either must be immobilized completely in plaster of

Paris or traction-suspension is required In treating every compound joint fracture the surgeon should bear in mind the probability of permanent limitation of motion or ankylosis and on this account immobilization of the joint in the most satisfactory position for future function is important

The shoulder and elbow should be immobilized with a plaster spica holding the arm in the salute position the elbow being held at a right angle The wrist should be held in slight hyperextension The thumb should be kept in abduction and in slight flexion and the fingers maintained in slight flexion The hip should be kept extended slightly abducted and must not be allowed to rotate externally The knee requires immobilization in the

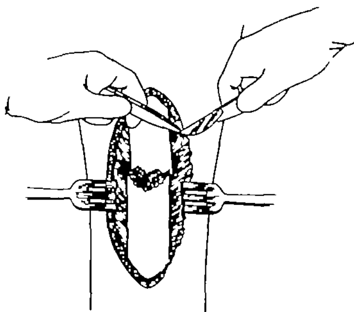


FIG 31 DEBRIDEMENT OF COMPOUND FRACTURES

The wound first is enlarged Then the entire skin edge is excised and the fascia opened widely The wound is retracted deeply, muscle tissue and fascia are cut away hematomas evacuated and bleeding vessels ligated (see next illustration)

extended position The ankle should be held at a 90-degree or 100-degree angle Lateral deformity of the foot should be avoided the foot being neither inverted nor everted When the toes are involved it is important to keep them straight

In many instances it is advisable to apply traction with suspension of the limb in splints For this purpose Steinmann pins or Kirschner wires may be inserted at the time of operation always as far from the wound as possible

If gross infection has developed it may be necessary to enlarge the wound and make additional incisions for drainage, dividing the deep fascia transversely to keep the wound wide open In all such cases absolute immo-

bilization is important and for this purpose plaster of Paris is most satisfactory

Follow-up treatment. Complete immobilization is important, as this decreases shock, and prevents the absorption of toxins and spreading of infection from the wound The patient never should be moved from the operating table before the plaster of Paris is applied as the position of the fragments thus may be lost and shock is increased After operation it is generally agreed that further treatment should consist of either the Carrel Dakin method or the Orr method

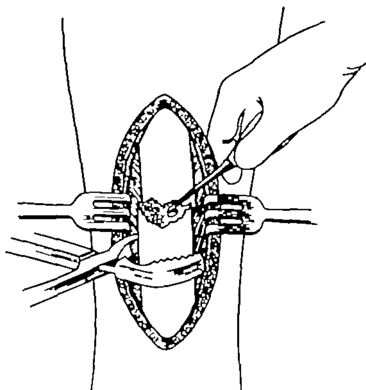


FIG 32 DEBRIDEMENT OF COMPOUND FRACTURES

The ends of the fragments are curetted dirt and foreign bodies are removed and the fracture is reduced if possible Finally the entire wound is washed thoroughly with soap if greasy or is irrigated with a large amount of salt solution

Modified Carrel Dakin method Sherman s modification of the original Carrel Dakin method is simple and effective After completion of the operation the wound is packed loosely with fluffy gauze saturated with an aqueous solution of sodium hypochlorite This is made by adding one part of Hychlorite to seven parts of water The solution should be made fresh daily as it is unstable and cannot be kept From one to three small rubber tubes with tiny perforations on their sides are laid in the packing deep in the wound the free end of each tube projecting through the bandage Before the patient leaves the operating table the limb is placed in a

splint, and upon reaching his bed the splint is suspended in a traction frame The nurse injects one or two drams of the hypochlorite solution into each tube every two hours The wound is redressed every second or third day, with special attention being given to prevention of contamination by aseptic technic on these occasions Daily bacterial counts may be made as the wound heals and instead of waiting for complete closure by granulation the wound may be sutured after the count has been reduced from 1 to 2 bacteria per field With this method the advantage of leaving the wound open is obvious, as anaerobic and pyogenic infection are successfully com



Fig 33 Compound Comminuted Fracture
After debridement and transfixion

bated sloughing tissue is dissolved and there is relatively little pain when the wound is redressed

Orr (closed plaster) method After the operation on the compound fracture has been finished the other and well known form of treatment is the closed plaster method This procedure was devised by Orr for chronic osteomyelitis and its great value in the treatment of compound fractures was proved by Trueta in the Spanish Civil War To be used safely the wound must have been operated upon within eight hours of the injury The Orr method is contraindicated when there is extreme crushing or risk of extensive necrosis of tissue or inadequate circulation The wound is left wide open and is packed loosely with vaseline gauze This part of the technic has been modified by Trueta who uses dry gauze by Gurd and McKim who use bipp and by Odelberg who advocates gauze saturated

with cod liver oil Recently Wallis and Dilworth have recommended the use of gauze saturated with lactose solution as rendering Orr's method practically odorless A well fitting circular plaster of Paris dressing or 'cast' is applied over the skin, with padding only over bony prominences The plaster must include the joints proximal and distal to the fracture, and the plaster should not be cut away over the wound as the hole would permit local edema to occur During the first two weeks the part should be kept elevated The fingers and toes must be watched for signs of circulatory disturbance and if these appear the plaster should be opened sufficiently to permit better circulation The patient may be transported almost immediately thus permitting early evacuation in war injuries However, it must be emphasized that all cases under this form of treatment must be kept under close observation Progress of the infection is judged by the patient's temperature and general condition The wound is not dressed until the plaster is changed several weeks later It is important to observe a strictly aseptic technic while changing the dressings, in order to avoid contamination At this time the wound is found lined with healthy granulation tissue With the Orr treatment the number of cases in which fever sepsis and general infection develop is almost nil The favorable results are due to leaving the wound open, the prevention of secondary infection by infrequent redressings adequate immobilization and the freedom from pain. In reporting on this form of treatment Trueta states that removal of the plaster on account of true clinical infection was necessary in less than 1 per cent of over 1000 cases In a report of 5,000 compound war fractures treated by the closed plaster method within six to eight hours and after wound healing had commenced only 20 cases of gas gangrene developed and only 20 amputations were performed There were only 37 deaths 15 being due to gas gangrene and 7 being due to septicemia

Orr recently has advocated transfixion or the combined use of steel pins and plaster of Paris for displaced compound fractures or those which cannot be controlled satisfactorily by plaster of Paris alone Pins are inserted in the bone proximal and distal to the fracture as far as possible from the wound These are incorporated in the plaster dressing while traction is applied on a fracture table or in a traction frame under the anesthesia These usually can be kept in for several weeks They may be withdrawn without applying new plaster

Compound fractures extending into joints likewise should be treated by a thorough debridement operation followed by immobilization in plaster of Paris or by some other form of adequate splinting In most civilian injuries the joint capsule should be sutured and the remainder of the wound should be left open although in war wounds it is considered advisable to leave the entire wound wide open routinely

Infected fracture wounds. Infection is common in severely lacerated and contused wounds especially in those occurring in the lower limb from war injuries Lack of adequate first aid splinting delay in operation, and failure to immobilize the affected part are common contributing causes of infection In addition to the common infection by staphylococci and streptococci carried into the interior of the wound from the skin surface, gas-bacillus and tetanus infection are especially dangerous, the two last



FIG 34 END-RESULT OF COMPOUND COMMINUTED FRACTURE
Same case as in previous illustration. Treated by Orr method combined with transfixion. Firm union without deformity and with only slight limitation of ankle movements

forms of infection are particularly common in war fractures Infection has developed in nearly every instance when foreign bodies were left in the wound with the exception of high velocity bullets

Staphylococcic and streptococcic infections These infections produce increased pain and swelling elevation of temperature and accelerated pulse malaise and chills Such signs usually appear by the second or third day Streptococcic infection may produce cellulitis erysipelas or septicemia Staphylococci in addition to producing a purulent wound and abscess formation may produce pyemia or septicemia

Prophylactic treatment, in addition to a prompt and thorough debridement operation followed by immobilization, consists of the local implantation of from 5 grams to 20 grams of sulfanilamide in the wound and the oral administration of sulfathiozole Sulfanilamide is considered more effective against streptococci and sulfathiazole is considered more effective against staphylococci The local use of these drugs inhibits the growth of organisms although it does not act specifically as an antiseptic It does not seriously injure tissues but acts as a mild irritant and causes a considerable delay in wound healing Implantation of the sulfonamides locally is more effective in the early treatment of wound infections than giving the drugs by mouth as a concentration up to 75–100 times greater can be obtained in the wound than can be produced by general administration When sulfonamides are implanted in the wound they should be used in the powdered and sterilized form

If the wound already has been closed the sutures should be removed at once so that it is wide open to provide adequate drainage If the wound is small and infection is present it should be greatly enlarged, in addition to making one or more large incisions for drainage and counter-drainage the deep fascia should be divided transversely in order that the depth of the wound will remain open When there is fluctuation make one or more long incisions for drainage cutting the deep fascia transversely The wound should not be packed dressings being applied only externally Then apply a large continuous warm boric acid compress or keep the dressings wet with a 3 per cent aqueous solution of sterilized sulfanilamide The part should be kept warm by means of an electric pad or heat cradle For oral administration the first dose of sulfonamides should be at least twice the amount of subsequent doses. These drugs are absorbed faster in powder form and if chewed than when swallowed in tablet form If vomiting prevents the usual oral administration they may be given by hypodermoclysis or venoclysis They should be given in dosage of 10 grains to 20 grains every four hours and usually may be administered safely for several days It has been suggested that the soldier be instructed to take 60 grains of sulfanilamide immediately after he has been injured During the entire period such drugs are taken it is advisable to check the blood level daily and to watch for anemia Sulfanilamide is not as well tolerated as sulfathiazole and it is believed that sulfadiazene is even better tolerated sulfadiazene also is said to be even more effective against the usual war wound infections Regardless of the effectiveness of chemotherapy in the prevention and treatment of wound infection its local or systemic use must not be regarded in any way as a substitute for a thorough debridement operation Staphylococcus antitoxin given intravenously is recommended for general staphylococcic septicemia Staphylococcus toxoid is recom

mended for the subacute and chronic forms of infection Transfusions may be necessary with pronounced septicemia and positive blood cultures repeated small transfusions are more beneficial than large transfusions given less frequently If plaster of Paris has been applied, a large window should be provided for complete access to the infected wound, or the plaster should be removed altogether however it is important to give adequate support to the limb by some form of splint and with profuse discharge a metal splint may be useful

Treatment of chronic infection When the infection of compound fractures becomes chronic it usually involves the bone Chronic osteomyelitis should be treated by removal of all involved bone with exposure of pus pockets The operation should be followed by either the modified Carrel Dakin treatment with the extremity suspended in a splint or by the Orr method The latter method is more practical in most instances The



FIG 35 MOST USEFUL POSITIONS FOR ANKYLOSIS
If ankylosis is expected after severe fractures or infections it is important to immobilize in the best position for future function

objectionable odor which develops with the Orr treatment is due to saprophytic infection which does not interfere with wound healing

Tetanus. There is a decided variance in the incidence of tetanus in different localities It is especially common in farming localities where cattle are present and where fields are fertilized with manure Puncture wounds are the chief source of tetanus in civil practice as the anaerobic spores thrive in relatively closed spaces rather than in wide open wounds Authorities are not in accord as to whether the toxin is absorbed through the motor nerve endings into the anterior horn cells or whether it is absorbed through the lymphatic vessels and is thus carried to the central nervous system. The period of incubation varies greatly but the average time is nine days The more peripheral the implantation the longer the period of incubation. The mortality rate from various statistics varies from 25 per cent to 47 per cent In a large number of unimmunized cases when trismus (closure of jaws) appeared within 24 hours after the onset of symptoms there was a mortality rate of 71 per cent when trismus appeared after other symptoms there was a mortality rate of 19 per cent in general

tetanus without trismus the mortality rate was 21 per cent A large series of cases occurring in World War I were studied, in those cases which received prophylactic injections the mortality rate was only 2 per cent

Prophylaxis Local treatment consists of enlarging every puncture wound, and all compound fractures should be opened widely *Prophylaxis* by three injections of toxoid gives protection for four years In civil practice a prophylactic injection of anti tetanus serum is advisable immediately after every puncture wound which occurs in street accidents, around stables and farms and should be given to all cases having deep lacerated wounds A preliminary test to determine whether or not the patient is sensitive to

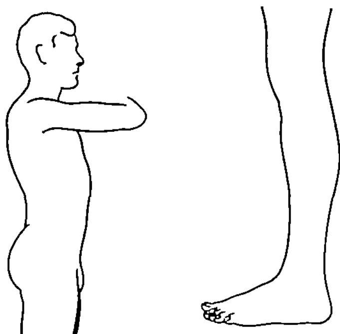


FIG 36 MOST USEFUL POSITIONS FOR ANKYLOSIS
If ankylosis is expected after severe fractures or infections it is important to immobilize in the best position for future use

horse serum should be made by the intradermal injection of 0 1 c c of the serum If no skin reaction appears within 20 minutes the entire amount of antitoxin is given at once The usual dose is 1 500 U.S.A units to be given in the muscles of the thigh or abdomen In decidedly suspicious cases the same injection should be repeated at the end of 10 days and again at the end of 20 days *The dose for children is relatively smaller* If the test shows the patient to be sensitive to serum small amounts of the serum should be given every half hour Adrenalin should be available for serum sickness The symptoms of this which appear about eight days after ward are urticaria puffiness of the eyes malaise and fever

Antitetanic serum for an existing case of tetanus should be given intra

venously or intramuscularly on the first day, 15,000 U S A units being repeated daily When given intravenously, the size of subsequent doses is reduced The daily amount is reduced gradually as tendency to spasm subsides Intraspinal injection is condemned Convulsions apparently spread the toxin and sedative drugs or avertin are recommended for the control of these

Gas-bacillus infection. This complication is relatively infrequent in peace times as compared with war times Gas-bacillus infection is often called gas gangrene the latter term should not be used unless the infection produces massive death of tissue In a large group of soldiers with war wounds which required amputation 47 per cent were cases of gas gangrene The mortality rate of gas gangrene in a large series of civil injuries occurring during the past decade was 50 per cent There was a correspondingly high mortality rate from this infection in the American Expeditionary Force in France during World War I In a series of gas gangrene cases developing after amputation for arteriosclerotic and diabetic gangrene the death rate was even higher being 59 per cent for the entire series and 75 per cent for the diabetic cases

The soil especially in farming regions where manure is used contains the gas-forming organisms of B Welchii and B oedematiens, and the anaerobes B sporogenes B histolyticus, and B perfringens Gas bacilli are present in the intestinal tract of man as well as of lower animals which fact explains the occasional occurrence of gas infection in wounds of the perineum and around the rectum

The infection is carried into the deep tissues by way of small puncture wounds by foreign bodies as bullets and projectiles and is especially common in compound fractures Peacetime puncture wounds and deep wounds which have been sutured are especially favorable to their growth Devitalized muscle is extremely susceptible to infection with gas bacilli and the natural resistance of the tissues to ordinary pyogenic infection is less effective against these anaerobes The organisms having been carried into the interior of the wound thrive in contused muscle deep fascial spaces, and in blood clots If the infection progresses it spreads quickly up and down the wounded muscle but there is little tendency to spread across from muscle to muscle If there has been interference with the main blood supply the infection may involve the entire limb

Gas bacillus infection is rapid, and in some cases may become well-established within a few hours In other instances the progress may be more gradual or insidious the condition not being recognized for several days after the bacteria have been carried into the wound The skin around the wound is not red and warm as when a pyogenic infection is present but is at first pale and swollen, and later assumes a peculiar brown color In well

advanced cases there is mottling and large blebs form and later these coalesce Gas crepitation in the underlying tissues often may be palpated, or may be heard with a stethoscope X ray films of the affected part may show the gas bubbles as the first indication of such an infection In a typical wound there is a thin exudate covering the muscles, which contains gas bubbles, later the exudate becomes thicker, more profuse and dark, with an offensive odor The odor has been likened to that of the autopsy room or of manure Culture of the wound usually is positive within 12 to 14 hours

Prophylaxis requires a thorough debridement of all compound fractures, including radical wound excision when there is extensive laceration or contusion of the tissues Every puncture wound should be decidedly enlarged Such treatment has greatly reduced the incidence of gas infection (See operation for compound fractures)

General treatment Chemotherapy is an important form of treatment which recently has been adopted Local use of sulfonamides is much more effective than their systemic administration as the tissue concentration in the wound is 75–100 times greater Sulfanilamide is implanted locally from 5 grams to 20 grams of the sterilized powder being spread through the interior of the wound with an anatomizer or a gloved finger When there are one or more puncture wounds as with gunshot injuries the skin edges should be cut out and twisted gauze coated with sulfanilamide powder should be drawn back and forth through the hole One of the sulfonamides also should be given by mouth 60 grains being the initial dose, with from 10 grains to 20 grains to be taken every four hours thereafter As the patient improves the daily amount may be reduced gradually During the administration of these drugs the blood level should be checked daily and anemia should be prevented by transfusion In combination with this drug therapy polyvalent antitoxin should be given prophylactically for all cases having severe contused and lacerated compound fracture wounds A preliminary test should be made to determine whether or not the patient is sensitive to horse serum (See Tetanus) The usual prophylactic dose of the mixed serum recommended contains 3 000 international units of B Welchii, 1 500 units of B septique and 1 000 units of B oedematiens and is given intravenously This should be added to 500 c c of normal saline solution In most instances three doses are sufficient and usually are given from four to eight hours apart In extreme cases an amount of 2½ times greater than this prophylactic dose should be given Dehydration and acidosis must be prevented and treated by infusions and transfusions usually are necessary

Local treatment The prognosis of gas-bacillus infection depends upon the patient s resistance the part of the body involved the virulence of the

organism, and the treatment The extent of operative treatment depends upon the severity of the individual case

In milder cases with superficial infection and without massive involvement of the muscles wide exposure and thorough drainage are important A long incision should be made and the deep fascia should be cut transversely to keep the wound open. The wound may be treated with sodium hypochlorite This form of treatment dissolves the blood clots and removes sloughing tissue by liquefaction (See Modified Carrel Dakin method) Wet dressings of zinc peroxide have been advocated to combat infection by the liberation of oxygen

In more severe cases in which one or more muscles are involved very large incisions should be made and the entire length of the involved muscles should be removed by blunt dissection only the fingers are used in order to avoid opening and carrying infection into uninvolved muscles or fascial planes If only a portion of a muscle is found to be involved the devitalized area should be cut out

When there is massive involvement and gangrene has spread on account of inadequate blood supply to the limb amputation should be performed immediately A guillotine form of amputation is preferable as it requires the least time it is the safest as the stump is left wide open The amputation should be performed at a good distance from the involved area

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CHAPTER IV

REDUCTION

Anesthesia. Almost every case requiring manipulation should have some form of anesthesia. Ether is the safest general anesthetic for inexperienced persons and produces satisfactory muscular relaxation Nitrous oxide does not produce sufficient relaxation for many fractures especially in ambulatory patients No general anesthetic should be given within four hours after eating because of the likelihood that food will be aspirated The splints should be kept on until the anesthesia is complete to protect the limb from further damage during the stage of excitement The recent use of intravenous anesthesia such as Pentothal sodium has been found very satisfactory for short manipulations and for fluoroscopic work. This form of general anesthesia should not be given to children or to persons having low blood pressure or serious organic disease it requires special care as the effects are rapid Spinal anesthesia may be used for fractures of the lower extremity but is contraindicated when the patient has low blood pressure Brachial plexus or nerve block anesthesia is satisfactory for the upper extremity

Local anesthesia Local anesthesia is of great advantage in the aged and in office practice also when general anesthesia is contraindicated and when assistants are not available It can be used to best advantage in recent cases before the bleeding around the fracture has clotted although it may be successful even several days after injury Infiltration anesthesia cannot be used in compound fractures when there are extensive blebs and abrasions on all sides of the limb or in impacted fractures As a 1 per cent or 2 per cent solution of procaine hydrochloride is injected into the hematoma around the fracture it spreads through the lacerated tissues and the fragments thus eliminating pain and muscle spasm The technic is as follows First produce a wheal with a fine needle and then while making suction insert a larger needle until blood from the hematoma appears in the syringe Then introduce from 10 c c to 20 c c of procaine the amount depending upon the age of the patient and size of the limb After a few minutes the fracture can be manipulated without pain If X ray examination immediately after the manipulation shows an unsatisfactory position of the fragments manipulation can be repeated.

Manipulation. The initial treatment to a great extent determines the final result Do not wait for swelling to subside before manipulation as swelling is reduced by reducing the fracture Delayed reduction usually

is found to be difficult reduction, furthermore, the displacement of a neglected fracture may cause nerve damage or serious disturbance of the circu

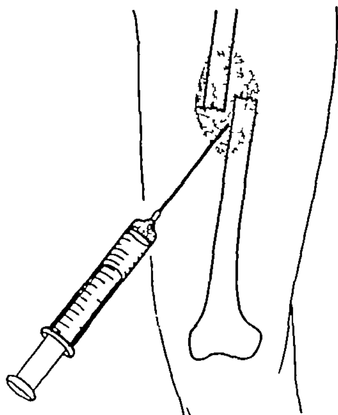


Fig 37 Local Anesthesia for Fresh Fractures

Before injecting the procaine hydrochloride a small quantity of blood should be drawn up into the syringe from the hematoma around the fragments thus insuring success of the anesthetic

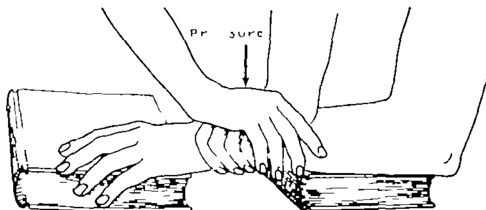


Fig 38 Method of Correcting the Angulation of Green-Stick Fractures or Malunion

lation If there is doubt as to the treatment of a difficult case it is far better to call a consultant at once than to meddle and manipulate repeat

edly Study the anatomy of the part affected, and visualize the fracture by having the X ray films before you when treating a case however, even with the films before him the physician should learn to feel intelligently with his fingers Do not attempt manipulation without anesthesia, as

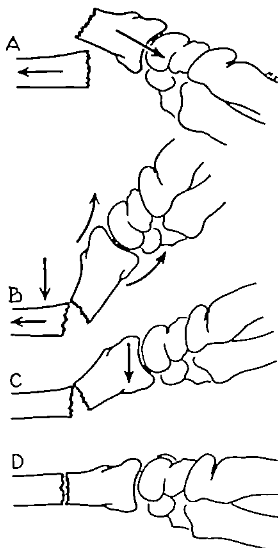


FIG 30 REDUCTION OF OVERRIDING FRACTURES BY ANGULATION
A traction and counter traction B hyperextension added to A thus securing impingement of the fragments C and D correction of the angulation (Adapted from Cotton)

this causes excruciating pain and the muscle spasm prevents reduction Manipulation should be as gentle as possible First apply traction in the axis of the bone and then bring the end of the movable fragment to meet the end of the immovable fragment by the angulation maneuver Success in manipulation requires not only a knowledge of the anatomy and visuali



Fig 40 Fractures of Forearm with Poor Operative Result

The screws were too short to hold well There is permanent deformity non union and the loose plate and screws must be removed



Fig 41 Comminuted Fractures of Leg

Operative result Skeletal traction failed to reduce the displacement Treated by open reduction and internal fixation with stainless steel plates and screws long enough to hold both cortices Returned to former work completely recovered

zation of the fragments it requires also the skill which is attained by practice While manipulation with the hands alone is sufficient for many cases the pull or leverage on the fragments by some form of skeletal

traction may be necessary Order X ray examination routinely after manipulation or immobilization of every fracture, and do not leave the patient until you have seen the films

Open reduction. A prominent author states that approximately 95 per cent of fractures may be reduced by conservative treatment This statement implies early attention and considerable skill On account of the risk of infection and the technical difficulties involved open reduction should be avoided whenever possible

Indications for open reduction are found in (1) failure at reduction by conservative methods (2) failure to maintain reduction, (3) joint fractures with displacement of fragments (4) the pressure of soft tissues between the fragments (5) neglected fractures in which the formation of callus prevents reduction (6) non-union

Fracture operations are technically difficult and those involving the large bones often cause considerable shock Rigid asepsis must be observed, as infection with consequent osteomyelitis is disastrous Although formerly it was customary to wait for a week or ten days before operating recently it has been found best to proceed as soon as the general condition of the patient is satisfactory In exposing the fracture the periosteum with its blood supply should be disturbed as little as possible and a hair line reduction is desirable Rigid internal fixation should be used Vitallium or stainless steel plates with machine screws usually do not require subsequent removal and permit early function while holding the fragments securely These materials do not produce foreign body reaction or electrolytic changes

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CHAPTER V

IMMOBILIZATION

The application of some form of splint is the first procedure in the treatment of every fractured limb This should never be postponed on account of swelling or bleeding The need of immediate immobilization of compound fractures is most urgent

Splinting As a general rule it can be stated that the limb should be immobilized in the same attitude which was required for reduction For instance the position of flexion and ulnar deviation at the wrist which is necessary for the reduction of a Colles fracture is the position for its immobilization Most fractures which can be reduced by manipulation require only simple splinting No attempt should be made to reduce fractures or to maintain reduction by tight dressings and extra room should be allowed for subsequent swelling The splinting or bandaging should be made snugger as swelling subsides during treatment

The standard emergency splints usually available in hospitals are the Thomas splint the Keller Blake or half ring Thomas splint for the lower extremity the Murray-Jones or hinged Thomas splint for the upper extremity the abduction or aeroplane splint for abducting the shoulder, the Taylor or spinal brace and the Thomas collar or adjustable cervical spine brace The various adjustable universal splints which often are sold to physicians seldom are as satisfactory for any fracture as a simple splint made for the individual requirements from wood wire mesh or plaster of Paris Malleable sheet metal splints are practical especially *for fractures of the small bones and can be cut to fit from thin aluminum* The most satisfactory material however and the nearest to being universal in its use is plaster of Paris

The use of plaster of Paris. Plaster conforms to the shape of the limb and is adaptable to whatever position is necessary for the individual fracture furthermore plaster dressings are light comfortable and inexpensive A practical knowledge of plaster technic is a valuable asset in the treatment of fractures although this requires considerable experience

Plaster bandages made by hand are more satisfactory than those sold by surgical supply houses These should be made by rubbing the best grade of Regular Dental plaster into crinoline of Number 32 mesh which has been torn into bandages of different lengths and widths The average plaster bandage is four inches wide and three yards long Plaster bandages should be kept in metal boxes in a dry location, but not near a

radiator They should be handled carefully as the powder is easily shaken out The materials and equipment necessary for applying plaster of Paris are a large bucket or deep basin for water various widths of plaster bandages sheet cotton bandages stockinet soft felt and strips of aluminum or bass-wood for reinforcement An orthopaedic or fracture table is useful for temporary traction and immobilization of major fractures If such a table is not available it is necessary to have at least a

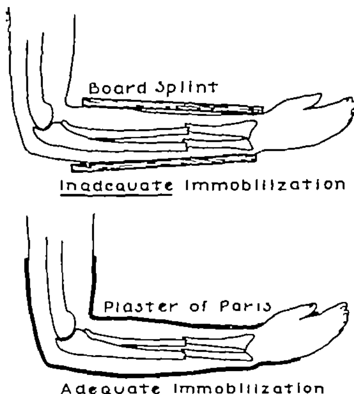


FIG 42 RELATIVE EFFICIENCY OF STOCK SPLINTS AND PLASTER OF PARIS

*The board splints do not fit the shape of the limb are not long enough and do not control the joints above and below the fracture

The plaster of Paris conforms to the contour of the limb and controls the joints above and below the fracture preventing angulation and rotation of the fragments

metal sacral rest for the application of plaster spicas for the femur Pulleys and ropes may be used for improvised traction

Application of plaster of Paris dressings The plaster should be long enough to include the joint above and below the fracture For the padded form of plaster cover the part with a thin layer of sheet cotton bandages adding several extra turns around the top and bottom Heavy cotton padding becomes packed down in a few days and permits too much motion Place blocks of felt which can be torn to desirable thickness over the cotton for padding of bony prominences When ready to apply the plas-

ter but not until then place one or two bandages at a time in lukewarm water and do not disturb them until the air bubbles cease to rise and they are to be used Plaster of Paris sets faster in warm water and more slowly in cool water The excess water in the bandage should not be wrung out but simply expressed by gently squeezing both ends of the

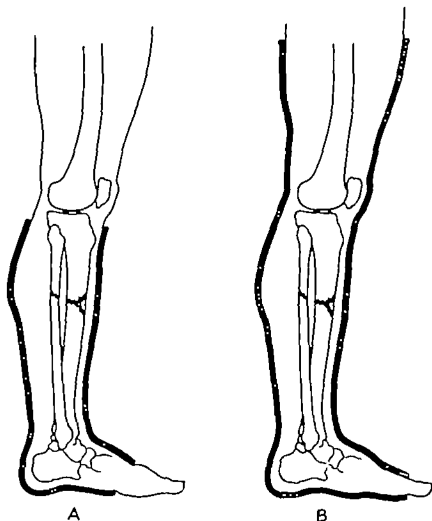


FIG 43 COMPARISON OF IMMOBILIZATION

A Inadequate immobilization The joints above and below the fracture should be included in the plaster Edema of the fore-foot occurs unless the plaster extends to the web of the toes B adequate immobilization Both joints above and below the fracture are included the plaster extends to the web of the toes

plaster at the same time until it has stopped dripping When plaster bandages are crumbly they have been rolled too tight or have not been immersed in the water long enough or the water in the pail has become saturated with plaster from many previous plaster bandages In order to strengthen the cast first apply a strip of wet plaster made by over lapping and rubbing together several layers of plaster bandage over a

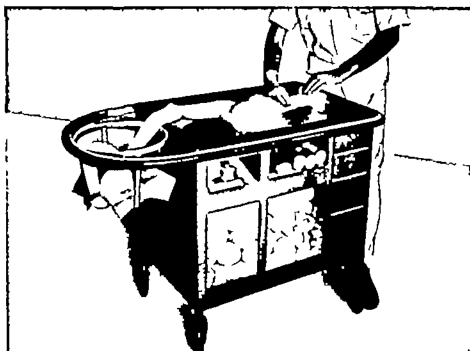


Fig 44 Plaster Cart for Hospital Use

The plaster cart has a metal top a rack for a pail of water bins for storage of plaster bandages cotton bandages and drawers for instruments The method of making plaster bandages is shown

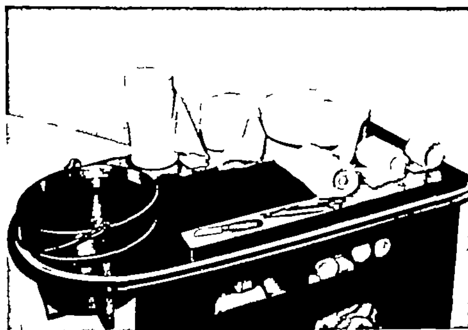


Fig 45 Materials for Application of Plaster of Paris

Stockinette of different widths sheet cotton bandages soft felt a pail of water a knife and large bandage scissors should be ready

table or board Then roll on the plaster bandages beginning at the end of the extremity and extending upward overlapping two-thirds of the width of the bandage at every turn It is important to avoid pulling the plaster bandages during their application as this causes constriction of the limb they should be rolled or pushed around Apply the plaster evenly avoiding any wrinkles and never reverse the turns because of the creases thus formed Rub the plaster continuously while it is being applied thereby making it a solid mass and molding it for a uniform fit Do not make the plaster heavier than necessary but reenforce it where there is

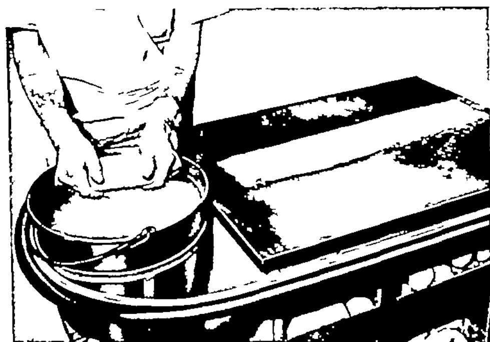


Fig 46 Plaster of Paris

The bandages are immersed in cold or warm water depending upon how fast the plaster should set for the individual requirements After no more air bubbles rise in the water the bandage is grasped at each end as the excess water is expressed through the mesh of the bandage but not through its ends A reverse or reenforcement strip of plaster made from a wet bandage also is shown

strain as at the axilla and groin For this reenforcement use reverses of plaster bandage strips of aluminum or pieces of moistened bass wood Slight angulation of fragments can be corrected by carefully molding the plaster as it hardens Last of all roll the top and bottom padding over the ends of the plaster dressing and fasten it with a few additional turns of plaster to prevent the edges of the plaster from cutting the skin Trim the plaster at the web of the fingers and toes so that the circulation can be watched For this purpose use an ordinary shoe knife sharpened with a wire edge When using circular plaster to immobilize fresh fractures bivalve it routinely to prevent excessive swelling or interference with the

circulation With the plaster thus cut the limb can be examined easily and physical therapy may be given without moving the fragments The best general tool for removing plaster of Paris is a shoe knife Removal also is facilitated by wetting the plaster with water for a few minutes

Application of unpadded plaster The use of unpadded plaster of Paris especially for forearm and ankle fractures is a decided advancement in treatment as it permits early protected function with a minimum of encumbrance However unpadded plaster must be used with discretion and only by those who have mastered plaster technic Unpadded plaster never should be applied when blebs or extreme swelling are present and the patient should be observed frequently for the first few days

Plaster of Paris splints Plaster splints are excellent for most simple fractures No padding is required and there is no danger of constricting the circulation Always use cool water as the plaster should set slowly,

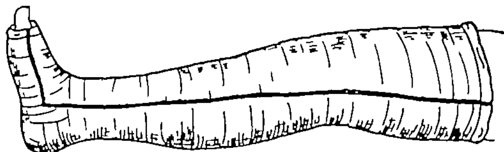


FIG 47 PRECAUTION WITH PLASTER OF PARIS
Circular plaster dressings or casts should be bivalved by cutting them on both sides as soon as they have hardened as a precaution against constriction edema As recovery progresses the anterior half may be discarded leaving the posterior half as a splint

and do not squeeze the water from the bandages Make a splint by overlapping and rubbing together ten or more layers of plaster bandage over a table or board Place this reverse immediately upon the limb smoothing it to fit closely and evenly to the skin surface as it hardens and then apply a gauze bandage to hold it in place

Plaster dressings and plaster splints can be protected from fluids and discharges by coating with cellulose acetate which is prepared according to the following formula To a two-quart jar containing two-thirds capacity of cellulose acetate and three ounces of sizing (Dimethyl phthalate A) add sufficient acetone to fill the jar Mix and stir occasionally adding a little more acetone to make the solution the consistency of thin syrup

Precautions for the use of plaster of Paris Do not permit an assistant to hold the limb under the heel or elbow as the consequent flattening of the plaster may cause painful pressure sloughs

Do not sprinkle water over the plaster while it is being applied, or afterward, as this makes it soggy. Adding plaster powder for a smooth finish is not necessary if the bandages have been properly applied.

Be careful to prevent angulation of a fracture while applying plaster. Order X ray examination routinely after the application of plaster.

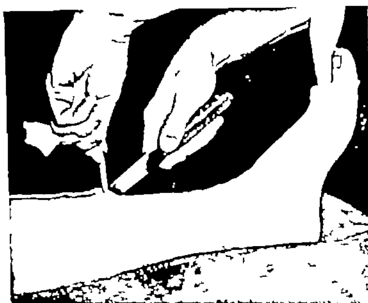


FIG 48 SIMPLE METHOD OF CUTTING PLASTER

A strip of muslin bandage is laid over the limb before the plaster of Paris is applied. Immediately afterward the plaster is cut while an upward pull on the bandage is maintained.

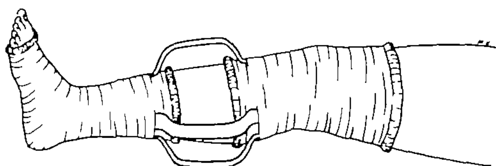


FIG 49 BRACKET-CAST FOR SUPPURATING COMPOUND FRACTURES

The two sections of plaster are joined by strips of iron, or by plaster of Paris ropes.

Angulation of the fragments can be corrected by cutting and patching the cast.

When plaster has been applied to fresh fractures the limb should be kept elevated for forty-eight hours to prevent excess swelling.

The fingers and toes should not be covered by plaster. They must be

observed frequently, and should be warm and pink; paleness, coldness and swelling indicate serious circulatory disturbance.

If a patient continues to complain of pain or a burning sensation over a bony prominence a pressure slough may be expected. Cut a window in the plaster without delay, place a piece of felt padding over the tender area and then apply another plaster bandage over this. Unless the window is closed in this manner there will be considerable local edema. A musty odor under plaster indicates a pressure ulcer or infection and requires investigation.

Treatment of fractures without immobilization. Although one of the principles of fracture treatment is immobilization while the fragments unite, there are exceptions to the general rule. Many fractures in the terminal phalanges of the hand and foot do not require splinting, impacted fractures in the neck of the humerus can be treated with a sling, and fractures in the upper portion of the fibula do not need immobilization. These conditions are treated best by early function within moderation. In such instances it is important to explain the condition and treatment to the patient in order to avoid dissatisfaction.

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CHAPTER VI

TRACTION

Some form of continuous pull or traction is required for most of the complete fractures in the long bones The displacement and overriding of the fragments is reduced or minimized by overcoming muscle spasm Angulation is corrected by making traction on the distal fragment in the same line with the proximal, uncontrollable fragment. When there is rotational displacement the lower fragment must be held rotated by the traction to meet the position of the upper fragment This form of treatment also prevents contractures in joints and does not result in as much limitation of motion as occurs with immobilization Traction, as any other form of treatment should be applied immediately, both in order to control shock and to secure complete reduction Heavy weight is applied for the first few hours for reduction after which less pull is required to hold the fragments in position By traction and suspension with splints, ropes and pulleys the circulation is not impaired and there is greater mechanical efficiency When the patient shifts his position in bed the traction should move with him (balanced traction) For this treatment some type of frame is attached to the bed the wooden Balkan frame being the most popular Two forms of continuous pull on the limb are commonly in use (1) skin or adhesive traction and (2) bone or skeletal traction In order to obtain satisfactory union with either the following points should be kept in mind (a) the direction of traction (b) the amount of weight required (c) sufficient counter traction (d) constant personal attention

Skin traction For this purpose a good quality of moleskin adhesive plaster is preferable to the zinc oxide plaster and should be fresh All the strips required should be cut and hung up ready for application, when only the thinner zinc oxide adhesive is available it is well to use a double thickness Then the skin is cleansed with mild soap and water A clipper or electric shaver may be used to cut off the heavy hairs but shaving with a razor removes epithelium and invites skin infection The skin may be painted lightly with compound tincture of benzoin or with an alcohol-acetone solution of Mercurochrome The strips of plaster are then laid smoothly on the sides of the limb with care to avoid wrinkles A snug spiral reverse bandage of flannel or muslin is next applied and finally criss-cross strips of narrow adhesive plaster are used to secure the bandage An ACE bandage is excellent for this purpose as it cannot cause constriction around the ankle or wrist A spreader is fastened

to the adhesive strips close to the end of the limb and to this a piece of $\frac{3}{16}$ inch braided rope is attached for immediate traction through small *awning pulleys attached to the Balkan frame All knots in the rope* should be fastened with adhesive plaster to prevent loosening

Other forms of adhesive material available for skin traction are spirit glue and liquid celluloid both of which can be used on the legs of small

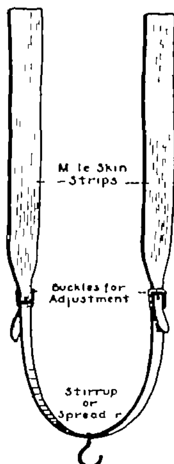


Fig 50 Equipment for Adhesive Traction
The width of the spreader can be adjusted to the individual limb

children which become wet and they also are useful for obtaining a hold *on small surfaces as fingers These adhesives irritate the skin of some* individuals although in most cases they stick well and may be left un disturbed for many weeks When applying them a pair of rubber gloves should be worn Flannel or muslin strips are soaked in the liquid and must be applied immediately as the adhesive material dries rapidly The formula for spirit glue is alcohol 50 c c Venice turpentine 5 gr benzine 25 c c Liquid celluloid glue is made by placing strips of cellu

loid in a covered jar and adding enough chemically pure acetone to form a consistency of syrup

Buck's extension This is a horizontal form of traction obtained by applying adhesive plaster to the extended limb It may be used for minor fractures of the femur without displacement A Thomas splint or a padded sling around the groin attached to the head of the bed is used for counter traction or the foot of the bed may be elevated for the same purpose

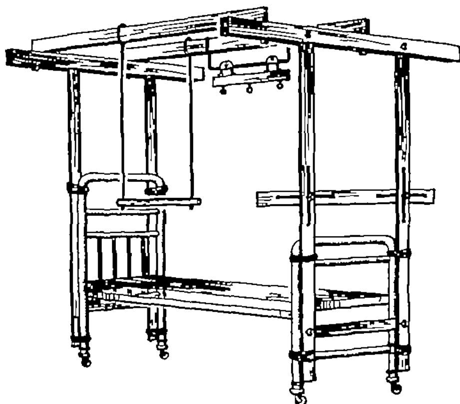


FIG 51 STANDARD ADJUSTABLE FRAME FOR TRACTION CASES
Note the trapeze which helps the patient in shifting his position

Bryant's suspension Perpendicular adhesive traction upon the lower extremity is satisfactory for fractures of the femur in children under eight years The upward pull of the weight over the pulleys should draw the pelvis just off the level of the bed The weight of the body combined with a pelvic band pinned to the mattress act as counter traction Another form of Bryant's traction is the suspension of both extremities with adhesive plaster strips which are simply tied to the overhead frame A coaptation splint may be applied to the limb at the site of fracture

Russell's traction By virtue of its mechanics of pulleys and diagonals this balanced traction exerts a pull equal to two and one-half times the

weight applied It is applicable to fractures in the shaft of the femur in all persons past the eighth year The pull is obtained on the leg and on the flexed knee Adhesive traction is applied only to the leg with the weight of the body and elevation of the foot of the bed acting as counter traction Small pulleys and braided rope should be used This method of stretching the thigh muscles holds the extremity suspended in a natural comfortable position and is effective in correcting overlapping of the fragments in a majority of the cases

Hoke's push and pull traction This combination of adhesive traction with a ratchet and double plaster spica depends upon the plaster on the unaffected limb for the "push" The Roger Anderson "well leg" splint is an adaptation of this principle



Fig 52. Skeletal Traction
Steinmann pin and handle used for drilling it through bone

Skeletal traction. No form of pull on the skin can be as mechanically efficient as a pull on the bone itself Skeletal traction has to a large extent replaced adhesive traction in the management of severe fractures of the long bones especially in adults Rotation and angulation are controlled and there is little tendency for it to become disarranged Physiotherapy and wound dressings may be applied without disturbing the traction and this form of traction does not irritate the skin If properly used it is more comfortable than adhesive traction and in most instances can be continued for several weeks or even longer without becoming loose or causing infection Skeletal traction can be used when skin traction has failed to overcome displacement and should be used routinely for most complete fractures of the tibia and fibula in adults The pull on bone is obtained by the insertion of a Steinmann pin Kirschner wire or ice-tongs. Al

though placing some form of steel through a limb constitutes an operation, there is little risk of damage if proper aseptic precautions are observed This procedure can be carried *out in bed under local anesthesia in order* to avoid unnecessary movement of the fragments and to attach the traction immediately

Steinmann pin traction is satisfactory in most instances A pointed, rigid stainless steel pin of desirable length and thickness is chosen, and after the exact location is determined it is inserted through the soft structures and directed through the bone by twisting it back and forth with a small handle The pin should pass through the bone at a right angle to the line

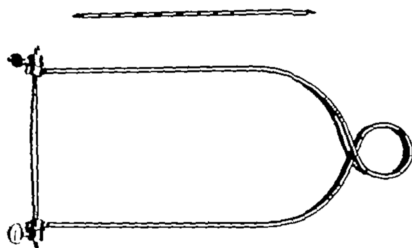


FIG. 53 SKELETAL TRACTION
Steinmann pin with Böhler stirrup attached for traction This *form of stirrup* revolves without loosening the pin A larger pin also is shown

of traction necessary Some surgeons prefer to use a hammer to drive the pin through the bone No incision should be made unless the bone is unusually hard even then the skin is only nicked on the side of entrance to permit drilling a small hole for the pin to fit tightly A bow or Böhler stirrup then is fastened to the pin and traction is applied immediately If the pin has been inserted properly it may be left undisturbed for several weeks without complications During this time periodic X ray examination with a portable unit is necessary The surgeon should not be misled by the apparent firmness of the fracture when it is manipulated while in *traction as* the traction itself produces considerable rigidity For removal the end which is to be drawn through the limb is rubbed thoroughly with an antiseptic and the pin is drawn out with a pair of pliers

Fixed traction Transfixion or external internal fixation is a combination of external immobilization by plaster of Paris and Steinmann pins inserted into the bone This form of treatment is especially applicable to

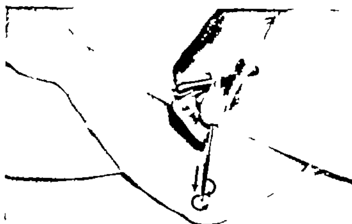


Fig 54 Skeletal Traction
Insertion of small Steinmann pin through the olecranon process for skeletal traction on the humerus No skin incision is necessary

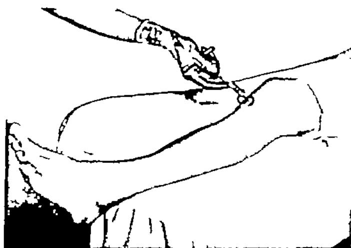


Fig 55 Skeletal Traction
Insertion of Steinmann pin through the tibial tubercle for skeletal traction on the femur No skin incision is necessary

overlapping oblique and comminuted fractures of the tibia and fibula in adults By its use continuous balanced traction in bed is avoided and the patient is able to use crutches during the first week A Roger Anderson Griswold or Böhler frame is required Steinmann pins are inserted proximally and distally to the fracture then the limb is placed in the

frame and traction is produced on the pin in the lower fragment by tightening the wing nut in the frame When sufficient pull has been obtained to overcome the shortening and bring the fragments into alinement, as



FIG 56 SKELETAL TRACTION
Insertion of Steinmann pin through the os calcis for skeletal traction on the leg No skin incision is necessary The pin can be inserted through the heel more easily than through the lower end of the tibia

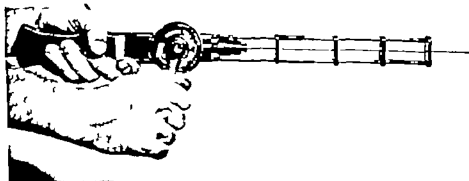


FIG 57 SKELETAL TRACTION KIRSCHNER DRILL WITH WIRE
As the wire penetrates the bone the operator prevents it from bending by advancing the four guide plates

determined by a portable fluoroscope or X ray machine an unpadded plaster of Paris dressing or cast is applied The plaster bandages must be immersed in cool water as they should set slowly and thus provide time for careful application to the bare skin without wrinkles The

pins are embedded in the plaster dressing as it is applied and then the limb is removed from the frame Obviously, such treatment should not

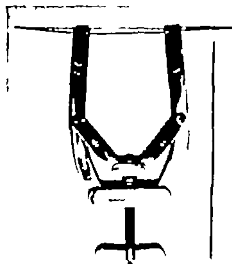


Fig 58. Skeletal Traction
Kirschner wire held in a spreader which tautens it and thus prevents the traction weight from bending it An additional Kirschner wire is shown

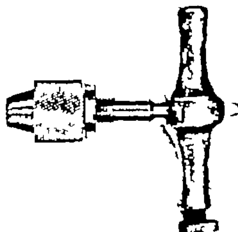


Fig 58a Useful Tool for Skeletal Traction
This fits both Kirschner wires and Steinmann pins and can be used for their removal as well as their insertion

be attempted by the novice as considerable skill in the application of unpadded plaster is necessary The patient must be kept under daily observation for at least the first week and if circulatory trouble occurs the plaster should be opened over the dorsum of the foot and leg

Transfixion also is being used for some fractures of the humerus, forearm bones and femur

Kirschner wire is made of stainless steel in various lengths and thicknesses one end being ground to a point It makes only a small hole in the skin and bone and is especially useful in smaller bones A special

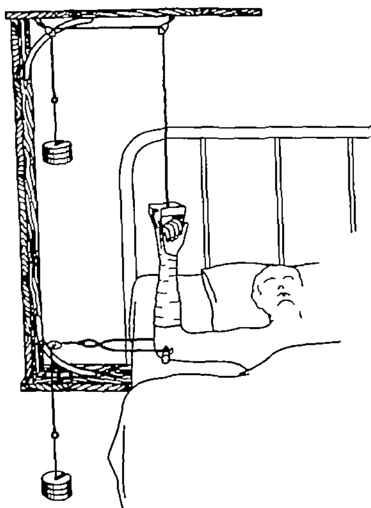


FIG 59 TRACTION-SUSPENSION FOR FRACTURES IN UPPER EXTREMITY

For fractures of the humerus elbow or forearm bones Adhesive traction is applied or the skeletal traction shown in the illustration is used depending on the individual case

hand drill which prevents it from buckling is used to drive it into the limb or a motor drill is very satisfactory After its insertion a tension bow is fastened to both ends to hold it taut and traction is applied immediately A Kirschner wire can be left undisturbed for many weeks even longer than a Steinmann pin It is removed simply by cutting off one end close to the skin with a pair of sterilized wire cutters and then pulling upon

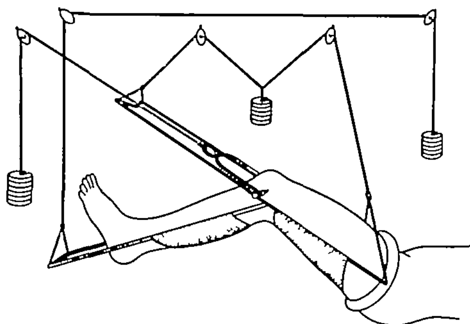


Fig 60 Traction-Suspension for Fractures in Lower Extremity
The Thomas splint is fitted with a Pierson attachment for flexion of the knee Adhesive plaster is used or the skeletal traction shown in the illustration is applied depending on the individual requirements

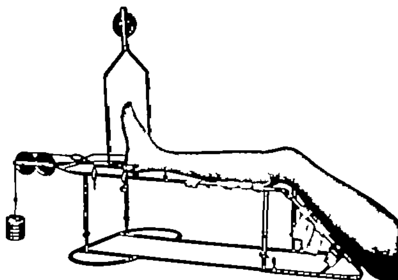


Fig 61 Braun Bohler Frame
This may be used for either skin traction or skeletal traction on the shaft of the femur and on the leg or on both When this splint is used no traction frame over the bed is necessary

the other end This form of skeletal traction also may be used for transfixion

Ice-tongs are seldom used except when the combination of lateral

compression and traction is necessary as in spreading fractures extending into joints A modication of ice-tongs may be applied to the skull for

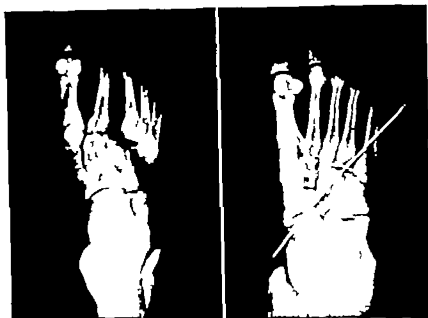


Fig 61a Transfixion with a Kirschner Wire

This simple method is useful for controlling fractures and dislocations of small bones the wire being drilled through the skin and affected bone securing a firm hold in adjacent bone Excellent result in tarso-metatarsal dislocation shown above

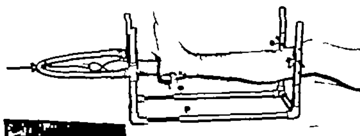


Fig 62 Author's Frame for Fixed Traction (Transfixion)

Under general or local anesthesia a Steinmann pin is driven through the os calcis and another is driven through the tibial tubercle The limb then is placed in the frame the upper pin engaging in two sections of metal tubing In addition to regulating the amount of traction the wing-nuts on the other end of the frame govern rotation of the distal fragment After reduction has been checked by X ray examination plaster of Paris is applied including the pins and the limb is removed from the frame This inexpensive frame also may be used in bed to provide continuous traction for severe compound fractures

traction on the neck For insertion of ice tongs ¼ inch incisions are made in the skin on both sides of the part and the jaws of the tongs are separately directed to a location just above the widest portion of the bone These

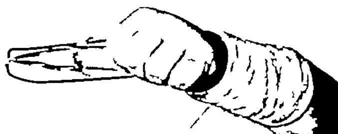


FIG 63 BANJO SPLINT

Skeletal traction with Kirschner wire for severe fractures of the hand or foot The amount of pull by the rubber band is regulated by bending the wire loop which is incorporated in the plaster of Paris The wire loop extends beyond the entire hand or foot when traction on more than one digit is necessary

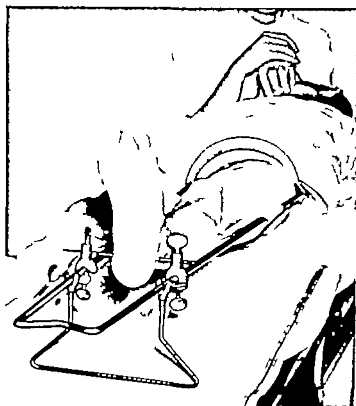


FIG 64 EMERGENCY FIXED SKELETAL TRACTION

This controls fractures of the femur and tibia satisfactorily A Steinmann pin is inserted through the body of the os calcis, and is fixed to the Thomas splint by means of Caldwell's lugs Such traction also can be used during debridement operations

are then tapped with a mallet until they penetrate the cortex and finally the set-screw on the handles is tightened to prevent displacement of the points Small pads of gauze are placed over the wounds and are not dis-

turbed subsequently Traction is obtained on a loop of rope fastened to the handles of the tongs

Roger Anderson, Stader, and Haynes have developed adjustable transfixion units which are applicable to nearly all major fractures of long bones Steel pins are inserted in the fragments and the fracture is reduced and immobilized by adjusting the rigid steel bars which accommodate the pins These units are proving valuable in the management of severe war fractures

Precautions for traction The importance of close attention to the details of any traction cannot be over-emphasized Traction should be applied immediately

In applying adhesive traction it is important to use only the best plaster, as poor grades irritate the skin The spreader must be fastened close

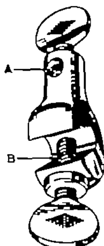


FIG 65 SHOWING DETAILS OF CLADWELL s LUG
A indicates the hole which accommodates a Steinmann pin The thumb screw is tightened at B to hold the lug on the side of a Thomas splint

to the heel so that it spreads the adhesive from the malleoli If the patient complains of the adhesive traction it is probable that the bandage and adhesive strips have slipped the consequent constriction must be relieved to prevent a pressure slough In traction on the lower limb the foot of the bed should be elevated enough for the patient s weight to act as counter traction unless sufficient elevation is used the patient slides down against the foot of the bed and a considerable amount of the pull is lost Braided rope and a good quality of awning pulleys are necessary for satisfactory traction as much of the mechanical efficiency of the pull is lacking if soft cord washline and poor pulleys are used It is important to inspect every detail of the set up daily in order to keep the ropes and pulleys in proper alinement and to prevent angulation of the limb Although such a warning would seem unnecessary the nurses should be instructed not to remove the weights while changing the bed covers

In applying skeletal traction rigid asepsis should be observed as infection in bone is serious It is important to avoid drilling a hole for the insertion of a Steinmann pin or Kirschner wire as a loose fit causes pain and invites infection The pin or wire must not be inserted through blebs through joints abrasions or hematomas also should not be placed through joints or in the epiphyses in children Excess weight applied to Kirschner wire may cause it to cut through a cancellous bone such as the os calcis If there is over pull or distraction with separation of the fragments the number of weights should be reduced to avoid non union If infection develops the pin or wire must be removed without delay It is important to have periodic X ray examinations to determine the position of the fragments and the amount of union and traction should not be removed until union is fairly well advanced

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CHAPTER VII

FOLLOW-UP TREATMENT

The follow up care of fracture cases is as important as the reduction The same doctor should treat the fracture case from start to finish In many instances disability and deformity have occurred following a very satisfactory reduction because too little attention was given to the details of after-care The management of fracture cases requires patience and the physician will have concluded his treatment only when the best possible result has been obtained X ray examination should be ordered periodically measurements should be made and the entire condition should be checked frequently If a slight angulation of the fragments is noted the splint or plaster should be changed and the callus molded by firm pressure as new splinting or plaster is applied There is no rule for the duration of immobilization as every case is different and the length of time depends upon the age of the patient and the individual injury Children's fractures require a relatively short time whereas in elderly persons and in fected fractures union occurs more slowly and prolonged immobilization is necessary How long the limb should be splinted and when to permit function can be determined by grasping it firmly with both hands and feeling for motion with the thumbs placed over the site of fracture Sensitiveness to pressure over the fracture indicates that the callus is not yet firm The fluoroscope also is helpful in determining whether or not there is any motion of the fragments

The psychology of fracture work is important The patient's condition should be explained to him so that he will cooperate intelligently in the details of the follow up treatment He should understand that the rapidity of his progress and the final result will depend to a great extent upon his own efforts By outlining a program of exercise and constructive occupation he will be encouraged to attain a certain amount of recovery in a stated time while his idle thoughts and doubts will be diverted to a more healthy state by striving for an objective The proper psychology with cases having injured backs is especially important

Physiotherapy The four essential forms are (1) heat (2) massage (3) exercise (4) electrical stimulation These various forms of physical therapy are of great value and should be commenced as soon after the injury as possible thus chronic swelling and other complications often can be prevented Such treatment also hastens repair of the fracture, and is helpful in restoring motion in muscles and joints The attending

physician should never transfer a case to a physiotherapist for further treatment, if treatment by someone else is given it should be under his supervision *Heat* can be applied early in the course of fracture treatment In traction cases the limb is exposed and heat may be applied with a therapeutic lamp on diathermia current Many fractures encased in plaster of Paris may be so treated by bivalving the plaster and removing

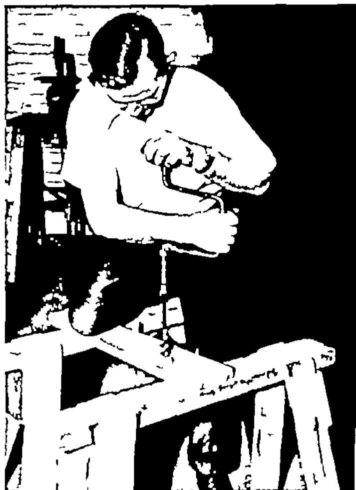


FIG 66 OCCUPATIONAL THERAPY FOR MEN
Restoring motions and strength in the upper extremity after fractures by constructive exercise

the anterior portion during the time of treatment The beneficial effects of the infra red rays may be secured at home by exposing the affected part to an ordinary electric household heater Paraffin baths for more prolonged hyperemia are especially useful in treating the stiffness and pain in hands and feet such as occurs after injuries of the soft tissues and with arthritic complications The use of heat in any form aids in the absorption of hemorrhage and the reestablishment of circulation

Massage is used to promote return of blood and lymphatic circulation, to loosen adhesions and to restore the patient's self-confidence Ordinary rubbing is of little value, and massage should be given by a trained person Massage is contraindicated in the presence of inflammation or infection

Electrical stimulation The chief benefit of this form of treatment is our ability to produce contractures of muscles during the early stage of callus formation before the patient can perform voluntary movements and engage in occupational therapy Electrical stimulation should be gentle and care must be used to avoid over treatment The Morton-Smart wave machine is the most satisfactory for this purpose

Exercises Active movements of the limb are a valuable aid to recovery of function Early and frequent use prevents muscular weakness and promotes repair of the fracture Voluntary movements in joints near fractures prevent contractures of the muscles and ligaments, and should be commenced as soon as possible Properly fitting splints and unpadded plaster of Paris dressings are very helpful in enabling the patient to exercise while the fracture unites thus reducing disability Patients should be taught to contract their muscles even while wearing splints or plaster Active motion never interferes with union as the patient stops at whatever range of motion causes strain upon the callus with consequent pain

Passive movements of joints near the fracture by the physician or physiotherapist never should be given before a fracture has united, as there is danger of straining the callus and thus causing delayed union or deformity from angulation Post traumatic contractures of joints may be improved by gentle but persistent passive movements given by a capable physiotherapist Forcible movements under anesthesia are occasionally indicated the joint being stretched slowly and continuously in all directions Violent manipulations cause considerable hemorrhage and a traumatic reaction from tearing and may result in even further restriction of motions Several gentle manipulations at weekly intervals will accomplish much more than one forcible stretching thus avoiding severe traumatic reactions and maintaining the confidence and cooperation of the patient

Restoration of function. Occupational therapy is of great help in restoring motion and strength Many patients recover strength and motion faster while engaging in certain prescribed forms of work and play than by massage and manipulation, as their attention to discomfort is diverted Furthermore they learn to help themselves instead of depending upon visits to the doctor's office or physical therapy department of the hospital This form of treatment is an important factor in the rehabilitation of injured workmen and in shortening the period of disability and has great possibilities in industrial surgery An ideal situation is created when the injured man is permitted to remain at some form of work after a minor fracture or to return to work while he is convalescing, thus his

moral and physical status is preserved by continued activity and earning capacity Useful constructive exercises are modeling basket weaving wood carving painting carpentry pipe fitting sheet metal work and gardening If possible these daily exercises should be preceded by heat and massage



Fig 67 Occupational Therapy for Weakness of Upper Limb and Back

The use of crutches should be explained to the patient *Before these* are used he should exercise and be able to get out of bed with little or no help standing against the side of the bed while bearing weight on the unaffected limb Thus confidence and sense of balance are restored before he attempts to walk Crutches should be long enough to permit the patient to stand upright and swing the crutches outward at an angle from the body *In standing the ends of the crutches should be placed* ahead of the patient thus forming two legs of the tripod necessary for balance The location of the hand grips should be adjusted to the length

of the patient's arm Crutch palsy with wrist-drop is caused by bearing weight on the axillary part of the crutch, instead of on the hand grip, the paralysis subsides soon after the cause has been corrected The patient is able to clear the floor better with the injured limb when a ½ inch lift is added to the shoe on the opposite foot When there is no further need of crutches a cane used on the opposite side to the fractured limb will provide

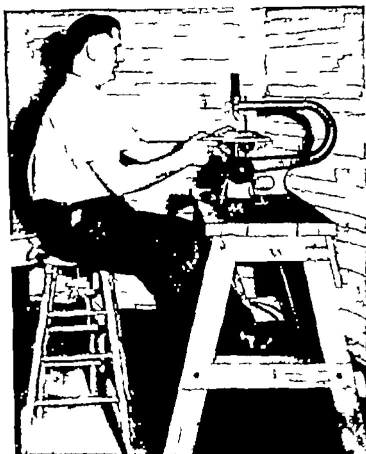


FIG 68 JIG-SAW FOR EXERCISING THE LOWER LIMB

While the patient is occupied by cutting patterns in wood his mind is diverted from weakness and discomfort in the knee and ankle which are used constantly to run the saw

enough support Many patients who are not able to use crutches on stairs can slide up and down in the sitting position step by step Walking behind a straight chair or wheel-chair may be substituted for crutches later

Ambulatory support. Snugly fitting unpadded plaster of Paris dressings give the best support and permit the most function On account of the possibility of circulatory complications all unpadded plaster of Paris dressings must be used with caution and should not be applied by the

novice All patients who wear unpadded casts should be under close observation The unpadded walking cast popularized by Böhler combines rigid support and weight bearing for minor ankle fractures without the need of crutches, thus patients are able to walk while the fracture unites and long disability is prevented Other valuable features of the walking cast are the remarkably free range of motions and the lack of edema after its removal Walking casts are not advisable for the early treatment of fractures in the shafts of the femur or tibia, on account of the danger of



FIG 69 TREATMENT OF EDEMA
Step block useful for elevating the foot of the bed, for counter traction and for treatment of edema in the lower limbs

displacement and angulation Protected weight-bearing later is useful in instances of delayed union after fractures of the leg

During the follow-up period braces and woven elastics also are useful for ambulatory support in selected cases

Unna's dressing or boot is valuable as a routine in the prevention of edema after plaster of Paris has been removed especially in the lower limb With this soft snug support the result of muscular function is a pumping effect of venous blood and lymph out of the area of stasis thus reestablishing the normal circulation The technic of application is

simple and worth learning A modification of Unna's zinc gelatin paste is prepared according to the following directions

Use zinc oxide 11 ounces pure gelatin 27 ounces water 27 ounces glycerin 43 ounces phenol 2 drams methyl salicylate 4 drams Mix the gelatin with the water and melt slowly on a water bath then stir the zinc oxide and glycerin together and add these to the gelatin meanwhile stirring vigorously As the mixture cools add the phenol and methyl salicylate Pour into a suitable mold and later cut the paste into blocks

Technic of applying Unna's boot. The limb should be kept in an elevated position until the dressing is applied Several pieces of the zinc gelatin paste are placed in a double boiler such as is used for cooking

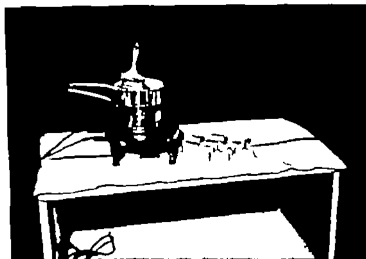


Fig 70 Unna's Paste
The paste is melted in a double boiler and then is applied with a large paintbrush

cereal and heated until the paste has softened to the consistency of thick syrup The entire limb is then coated with the warm paste by means of a broad paint brush Then a gauze bandage is applied snugly and smoothly extending from the web of the toes to the top of the calf Paste is applied again and over this another gauze bandage is wound The dressing is then rubbed so that the excess paste permeates the bandage It becomes dry after a few minutes and provides a snug somewhat elastic boot which gives support to both the circulation and the ligaments The elastic and adhesive Elastoplast bandage accomplishes the same purpose Any such support can be worn for about four weeks If at the end of this time the patient reports that the dressing feels tight toward the end of the day a fresh dressing should be applied in a similar manner and so on until the tendency to edema has passed

Causes for failure in recovery The reason for failure or delay in re

covery may be one of the following (1) pre-existing inflammation in soft structures or joints, of a 'rheumatic' nature, (2) traumatic arthritis (3) painful post traumatic osteoporosis with decalcification, (4) phlebitis, (5) anemia or constitutional disease, (6) neurosis or hysteria (7) malingery

Treatment of delayed union The commonest cause of delayed union in closed fractures is inadequate splinting Fractures in certain locations as the neck of the femur and the wrist joint unite more slowly than the average Most cases respond to further immobilization and



FIG 71 UNNA'S BOOT

This is made by applying the paste to the skin then over stockinet and finally over a gauze bandage It is valuable adjunct in the treatment of injuries in the lower limb as its application after the removal of plaster of Paris prevents edema The dressing should extend from the web of the toes to just below the knee

frequent applications of heat The benefit from the administration of lime salts alone or with vitamins is doubtful Cevitamic acid theelin also hydrochloric acid have been advised but as yet their values have not been proven Hyperemia by damming back the venous blood has been found helpful and may be produced by winding a piece of garter elastic around the limb twice daily The percussion treatment striking the end of the extremity with the ulnar side of the hand fifty times daily is recommended A conservative operation which is successful in many cases consists of making multiple drill holes across the site of fracture through two or three small skin incisions

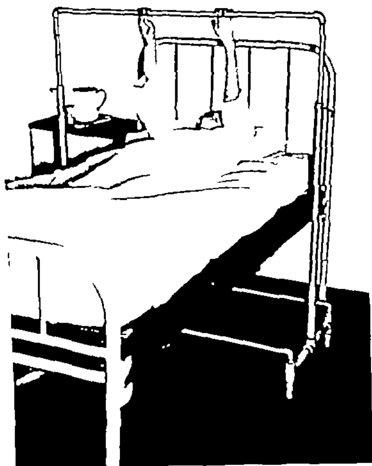


Fig 72 Adjustable Trapeze Frame

This enables the patients to shift their position in bed The ordinary fracture frame over the bed thus is eliminated



Fig 73 Post Traumatic Osteoporosis or Acute Bone Atrophy

This painful disability may occur soon after minor injuries involving joints especially and wrist and ankle Generalized decalcification shown by X ray examination is characteristic

covery may be one of the following (1) pre-existing inflammation in soft structures or joints, of a "rheumatic nature (2) traumatic arthritis, (3) painful post traumatic osteoporosis with decalcification (4) phlebitis (5) anemia or constitutional disease (6) neurosis or hysteria (7) malingery

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affected, for instance overlapping of fragments in the humerus is not serious and is seldom noticed but when an adult has shortening in the lower limb there is a permanent disability and limp Angulation of the fragments causes a more serious disability than overlapping with good alinement Angulation near a joint is more disabling than at some distance from it Even with perfect position and union of the fracture a painful joint may cause a permanent disability The patient is always much more satisfied with the result if he has had a clear understanding of his condition throughout the course of treatment He should understand that fractures are difficult to treat and that it is impossible to foretell the end result in any case A perfect result after a fracture, with no deformity, with complete joint movements and without external signs of injury is uncommon

In evaluating the result in industrial cases, the following outline will be useful

Plan for Determining Disability

Date *Examination for* *Name* *Address* *Age*

History Occupation in detail Date of injury Duration of disability Details of accident Subsequent progress Past treatment and by whom given Date of return to work (if returned) and nature of this work Past history including previous injuries rheumatic conditions or other complaints

Examination Complaints note indicated points direction of referred pain intensity modalities associated symptoms sincerity (malingery?)

Inspection note general condition temperature pulse deformity firmness of union of fracture scars swelling atrophy rigidity local circulation *Function* note gait general function local function probable cause of restricted function *Measurements* (comparative) length circumference Range of active motion range of passive motion Ability to pull push and lift Handgrips Motion in adjacent joints

Complications Neurological Circulatory Arthritic *Reflexes* patellar Achilles biceps *Focal infection* dental tonsillar prostatic etc Constipation?

X-rays when and where taken reports

Diagnosis

Comment: Did present condition follow injury during occupation? Is there an aggravation of any pre-existing abnormal condition? State present disability for former work in per cent and duration Estimate future disability for former work in per cent and duration also for other types of work

Evaluation of disability Consider the individual and his occupation the mechanics of the affected part his coördination and agility general strength and endurance his safety in occupation ability for usual occupation ability to secure employment and re-adaptability

Functional Factors in Upper Extremity Consider thumb-and finger action Ability to grasp squeeze hold reach lift and carry Ability to place hand where necessary What handicap is weakness of limitation or movement in thumb and fingers wrist elbow or shoulder? Endurance Re adaptability Compare with other upper extremity

Treatment of non union The only successful treatment is radical operation After freshening the fragments by removing all of the heavy fibrous tissue and reaming them out until the medullary canal is exposed they are patched with a massive on lay bone graft obtained from

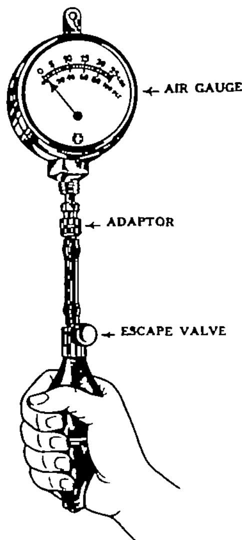


FIG 74 AUTHOR'S PNEUMATIC DYNAMOMETER
The rubber bulb is easily grasped for measuring the strength of the hand during convalescence from injuries of the upper limb

another limb This graft is fastened securely with stainless steel or Vitallium screws

Determination of the end result. The end result of a fracture is determined by (1) the state of union (2) the function and (3) the contour of the part The occupation of the patient, social conditions age and sex also must be considered The result likewise depends upon the part

CHAPTER VIII

BONES OF THE SKULL AND FACE

Fractures of the skull The treatment of head injuries is not considered in this book, as a fracture of the skull is usually of minor importance, injury to the brain being the chief consideration A careful history, if obtainable is important for diagnostic and medicolegal purposes A large proportion of the cases are unable to give a history Inquiry as to the severity of an accident cannot be relied upon to determine the possibility of damage to the brain The accessory sinuses, orbit and inner ear may be involved in fractures of the skull Often compound fractures of the skull with laceration of the scalp are depressed and comminuted Fractures in the vault of the skull may be accompanied by little or no intracranial trauma, on the other hand, fractures at the base often cause serious damage to the brain

Local signs of cranial injuries are scalp wound, fissure or depression in the outer table of the skull crepitus escape of blood cerebrospinal fluid or brain tissue, and ecchymosis Ecchymosis is subconjunctival with fractures in the anterior fossa, and perimastoid with fractures in the posterior fossa

General symptoms are unconsciousness which may be immediate or may occur later vomiting headache, and variation in respiration pulse blood pressure and temperature

Localizing signs are deviation of the eyes change in pupillary reactions, alteration in the deep reflexes on one side of the body as compared with those on the other side and disturbances of the cranial nerves

Routine stereoscopic X ray examination should be made but if the condition of the patient is very critical he should not be moved for this as general examinations and observation are of primary importance The films are easily misinterpreted and diagnosis must be made only by a roentgenologist Every injury of the head should be regarded as having produced intracranial damage until proven otherwise and the patient should be kept in bed under close observation

Complete neurological otological and ophthalmoscopic examinations should be routine Lumbar puncture for examination of the cerebrospinal fluid and determination of the pressure are valuable diagnostic procedures Differential diagnosis is important and should include alcoholism uremia spontaneous hemorrhage embolism and hysteria For details of diagnosis and treatment consult textbooks on cranial injuries

Functional Factors in Lower Extremity Weight bearing ability agility and balance location stepping and climbing ability endurance ability for usual vocation Compare with other lower extremity

General Estimation of Disability for Industry computed on a basis of 100 per cent 20 per cent value of right upper extremity as a whole 20 per cent value of left upper extremity as a whole 20 per cent value of right foot and ankle together 20 per cent value of left foot and ankle together 10 per cent value of right knee 10 per cent value of left knee

Factors in Re-adaptability age occupation experience training mentality willingness

Recommendations: Treatment Occupational therapy Work Other examinations

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CHAPTER VIII

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Local signs of cranial injuries are scalp wound, fissure or depression in the outer table of the skull, crepitus, escape of blood, cerebrospinal fluid or brain tissue, and ecchymosis. Ecchymosis is subconjunctival with fractures in the anterior fossa, and perimastoid with fractures in the posterior fossa.

General symptoms are unconsciousness, which may be immediate or may occur later, vomiting, headache, and variation in respiration, pulse, blood pressure and temperature.

Localizing signs are deviation of the eyes, change in pupillary reactions, alteration in the deep reflexes on one side of the body as compared with those on the other side, and disturbances of the cranial nerves.

Routine stereoscopic X-ray examination should be made, but if the condition of the patient is very critical he should not be moved for this, as general examinations and observation are of primary importance. The films are easily misinterpreted and diagnosis must be made only by a roentgenologist. Every injury of the head should be regarded as having produced intracranial damage until proven otherwise, and the patient should be kept in bed under close observation.

Complete neurological, otological and ophthalmoscopic examinations should be routine. Lumbar puncture for examination of the cerebrospinal fluid and determination of the pressure are valuable diagnostic procedures. Differential diagnosis is important and should include alcoholism, uremia, spontaneous hemorrhage, embolism and hysteria. For details of diagnosis and treatment consult textbooks on cranial injuries.

Fractures of the nasal bones. *Etiology* On account of the exposed position fractures of the nose are the commonest of the bones in the face Comminuted fractures with depression are the result of a blow from straight ahead while those with lateral displacement are caused by a blow from the side Most of the severe fractures of the nose are the result of automobile accidents and often are accompanied by fractures of the forehead and upper jaw Many of these fractures are compound, with laceration of the mucous membrane of the nares

Examination These injuries may be overlooked at the time of the accident because of other more serious conditions There is extreme swelling ecchymosis and nose bleed The swelling frequently hides more damage and deformity than is apparent on superficial inspection Palpate gently for in grasping the nose roughly crepitation and abnormal mobility may not be detected Use a head mirror with artificial light, and apply novocaine and adrenalin to the mucous membrane for anesthesia and ischemia.

When the air passage is blocked use a nasal speculum sometimes while opening the speculum in the nostril the fragments will be reduced with a click Order X ray examination in every case for your record The films may show also fractures of other bones of the face

Complications Some of the injuries are followed by considerable hemorrhage Bone infection from the open wound may occur There may be a permanent depression of the bridge of the nose lateral deformity and interference with the air passage

Prognosis Deformity can be corrected only by prompt attention and thorough reduction Fractures of the nose too often are followed by deformity on account of poor treatment These fractures unite rapidly and correction by manipulation is practically impossible after two weeks Residual deformity externally can be corrected only by operation Internal deformity with marked deflection of the septum also requires an operation

Treatment Lacerations and compound fracture wounds should be cleansed well and sutured with fine silk The correction of displaced fractures of the nose is important not only from a functional aspect but also from the esthetic point of view Treat the case immediately using local anesthesia, or general anesthesia administered through the mouth. Correct the internal deformity by spreading a pair of Kelly forceps as they are held in the nostril This form of hemostat is curved with rounded ends At the same time make digital counter pressure upon the nose externally Insert vaseline gauze packing or a rubber tube for internal splinting If unable to correct the deformity a consultation should be

arranged Adhesive strapping across the bridge of the nose is useless Remove the packing daily, on account of the danger of infection After ten days all dressings or splinting should be stopped, and an oil spray prescribed Later a submucous operation may be necessary if a marked deviation of the septum exists Plastic operations are indicated for external deformity

Fractures of the malar bone *Etiology* These injuries are caused by smashing blows Depressed fractures are the most common type and are frequently found accompanying fractures of adjacent bones, such as those of the orbit nose and maxilla The line of fracture usually extends through one of the processes of the malar bone

Examination These fractures are frequently undiagnosed because of the marked tenderness and bogginess of the cheek Palpate bimanually standing behind the patient feeling for depression and irregularity Crepitation and abnormal mobility are absent when the fragments are impacted X ray examination is useful in diagnosis and treatment For this the film should be held in the vertical direction

Complications A depression deformity may be present but apparent only after the swelling has subsided There may be limitation of motion in the jaw Involvement of the orbital floor may injure the infraorbital nerve

Prognosis Union is firm in four weeks A good esthetic result may be expected after reduction of any existing deformity

Treatment These fractures should be reduced promptly on account of the early formation of callus Give general anesthesia and manipulate bimanually If this is not effective wash the face with soap and water and apply an antiseptic to the skin Then insert the pointed jaws of a stout towel clip through the skin and into the displaced fragment, and make traction with a rocking motion If this form of treatment is unsuccessful the fracture should be reduced by leverage which is accomplished by introducing a curved periosteum elevator subcutaneously and at some distance from the fracture No splinting is required and follow up treatment consists only of light massage

Fractures of the maxilla and mandible *Etiology* These bones are frequently damaged on account of their prominent position Fractures of the jaws are caused not only by external traumatism but also by internal violence during dental extraction and by disease Fractures of the maxilla are linear or comminuted with little or no displacement and often are associated with fractures of the nasal or molar bones Fractures of the mandible occur most frequently in the alveolar process and also are found in the ramus symphysis and condyloid process Fractures of the

mandible are frequently displaced and are difficult for the physician to manage Indirect violence from a blow on the side of the jaw produces a fracture at the angle of the mandible on the opposite side.

Examination Pain is localized and may also be referred and is increased by movements There may be bleeding from the mouth loss of power to chew or to occlude the teeth drooping of the corner of the mouth anesthesia and paresthesia

Be suspicious of bleeding points in the gum after a blow upon the jaw Look and feel externally then look and feel within the mouth Compare one side of the jaw with the other by gentle palpation X ray examination should be made externally and through the mouth

Complications Deformity produces mal-occlusion of the teeth Some of these fractures become infected from the extension of pyorrhea or periapical disease with subsequent osteomyelitis and non union

Prognosis The result depends upon the age of the patient the site and character of fracture the promptness and type of treatment and whether or not there is any infection When the fracture is near the condyles there may be temporary or permanent stiffness in the temporo-mandibular joints Several weeks or more are required for union Early X ray examination is not dependable for demonstrating union as many cases become firmly united before callus can be seen in the films

Treatment The jaws should be held together temporarily with a four tail bandage the bandage supporting the chin and extending over the top of the head An antiseptic mouthwash should be used frequently All fractures of the jaws should be treated in cooperation with or by a skilled dental surgeon Muscle contraction which prevents reduction is counteracted by wiring the teeth in the upper and lower jaws together the alinement of the teeth with approximation of the fragments is accomplished by daily adjustment of the wires When such fixation is used the patient can take only liquid diet When the natural teeth are absent an interdental splint is necessary

Precautions Order X ray examination routinely after injuries of the jaws as otherwise linear fractures may escape detection Differentiate fracture and dislocation Let the dental surgeon take the active part in the treatment of these injuries and thus avoid trouble Open operations for wiring the fragments are not only unnecessary but should be avoided on account of the danger of infection and non-union

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CHAPTER IX

VERTEBRAE

Etiology The spine may be regarded as a series of interlocking bones which serve a double purpose of being the mainstay of the trunk and forming a channel for the spinal cord and its branches The spinal canal extends from the foramen magnum to the coccyx although the cord ends at the lower part of the first lumbar vertebra Fractures of the vertebrae are caused by direct and by indirect force The body lamina, the transverse process or the spinous process of a vertebra may be involved

Compression fractures of the vertebral body occur most often where the movable portions of the spine join the relatively immovable portions as at the cervico-dorsal and dorso-lumbar areas The dorsal vertebrae seldom are fractured as they are less mobile and protected by the ribs Compression fracture occurs most often in the body of the first lumbar vertebra where the bone is cancellous The usual form of injury is a jack knifing' or sudden extreme flexion of the spine which occurs when a person falls from a considerable height Compression fracture is seen also after automobile collisions and may be caused by a heavy weight falling on the shoulder A considerable number of persons who fall in the standing position have a compression fracture of the heels in addition to the compression fracture in the spine The recent use of metrazol in psychiatry not infrequently has caused fractures in the spine

Fractures of the spinous process are due to direct injury and are most common in the lumbar region and also occur in the lower cervical region, as in these regions they are most prominent

The transverse processes are usually fractured by indirect violence being torn off by strong muscular contraction these injuries may be considered as sprain fractures

Fractures of the laminae are usually linear and are most often caused by direct impact if depressed or comminuted the spinal cord may be involved by pressure or laceration

Fracture-dislocations occur most often in the neck where cord involvement is frequent These are caused by such accidents as diving into shallow water and being thrown against the ceiling of an automobile. Hyperflexion may cause compression fractures in the bodies of the upper cervical vertebrae 50 per cent of all fractures of the spine are of the compression type

Examination. Suspect a fracture in the spine after every severe fall or

automobile accident although soreness and stiffness may be the only symptoms In many cases the patient complains only of a stiff neck or of moderate backache, or if there are multiple injuries may complain of pain elsewhere from a relatively trivial condition There may be pain in the abdomen or chest with abdominal distention and spasm of the back muscles Tenderness over the spinous processes is common Wedge compression fractures cause posterior angulation deformity of the spine, but general compression of the vertebrae does not cause deformity



Fig 75 Compression Fracture in the Cervical Spine
The anterior wedging is characteristic Complete recovery after wearing a plaster of Paris collar for two months then a cervical brace for four months

Do not overlook the serious nature of a vertebral fracture in the absence of cord symptoms nor the gravity of cord symptoms when there are no apparent signs of fracture In unconscious or drunken cases the loss of reflexes or presence of priapism denotes spinal injury Pressure upon the cord is determined by the Queckenstedt test for which a spinal manometer with lumbar puncture is used A prompt rise of fluid in the manometer when the internal jugular veins are compressed denotes absence of pressure on the cord likewise a prompt fall in the fluid when the jugulars are released denotes the same The outlook is grave if there is (1) early and

persistent priapism (2) early formation of trophic ulcers, (3) early edema of the limbs When these conditions appear a few days after the injury they denote hopeless destruction of the cord

The signs of cord injury in the cervical spine vary from pain and numbness in the arms and rigidity in the neck to those of a fatal issue For a short time after injury there may be abnormal mobility without muscle spasm but this is soon followed by muscular rigidity and deformity

Fractures of the dorsal vertebrae cause severe shock The usual findings are rigidity of the back tenderness over the spinous process with increased pain on percussion and often generalized abdominal tenderness The pain and muscle spasm in the back are aggravated by the tension produced

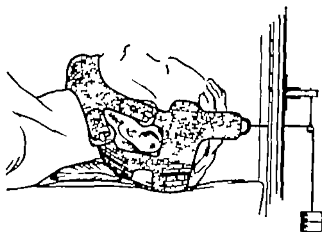


FIG 76 TEMPORARY TRACTION WITH GLISSON SLING

Note the pillow beneath the neck for maintaining hyperextension For prolonged and more effective traction required by severe fractures and dislocations Crutchfield tongs should be inserted in the skull

by moving the lower extremities Compression fractures with wedging produce typical posterior angulation deformity without crepitus

Fractures in the lumbar region are not accompanied by as much shock as severe injuries higher in the spine The back is rigid on account of muscle spasm and movements cause pain Fractures of the spinous or transverse processes produce pain on extreme movements local tenderness and rigidity and sometimes crepitus is elicited

X ray examination with a portable apparatus should be made immediately and for this the patient should not be moved A lateral view of the spine should be secured as well as the anteroposterior view Congenital anomalies of the processes should not be mistaken for minor fractures Immediate consultation should be requested for all severe back injuries

Complications. Frequent complications of spinal fractures are ileus spinal cord damage hypostasis and deformity The cord may be (1)

injured by pressure due to displacement of bone or to hemorrhage, (2) it may be lacerated and partially divided, (3) it may be completely severed Cord damage is seen most commonly in lower cervical and upper dorsal injuries

Prognosis. Minor fractures in the articular surfaces frequently are followed by permanent limitation of motion and posterior nerve root pain The mortality from major fractures in the upper cervical spine is high, severe fracture-dislocations and compression fractures often causing immediate death There is about 50 per cent mortality with fractures of the odontoid process of the axis on account of cord damage from displacement of the atlas When the lower cervical spine is involved by a major injury death usually occurs from respiratory failure or ascending myelitis

Patients having uncomplicated compression fractures in the dorsal region usually recover completely under the proper care as this portion of the spinal column is not subject to much movement or as much strain as the other portions Uncorrected wedging produces permanent kyphosis Compression fractures in the posterior portion of the vertebral body or in the articular processes may produce serious and irreparable cord damage Incomplete paraplegia may be caused by the initial injury or by the pressure of bone or hemorrhage in the canal With severe fractures infection of the urinary tract is the most common cause of death and is chiefly due to repeated catheterization Flaccid paralysis is always a grave sign Total division of the cord causes death from pneumonia decubitus ulcers ascending myelitis and ascending urinary infection regardless of the best care

Minor fractures of the lumbar vertebrae may cause disability for heavy work due to chronic aching and stiffness in the lower back on account of aggravation of a pre-existing arthritis In many instances X ray examination after fractures of the transverse processes shows only fibrous union, but non-union seldom causes much pain Compression fractures without cord damage do not cause permanent disability if properly treated however subsequent aching in the lower portion of the back after such an injury is common in persons over 45 years because of arthritic changes in the joints of the spine which also are injured Failure to reduce compression fractures results in a kyphosis deformity with permanent pain and weakness on account of disturbance in the relation of the facets of the spinal column Incomplete paralysis may subside after lumbar puncture and after reduction of the wedge-shaped deformity by hyper-extension Severe damage to the first lumbar vertebra with complete paralysis frequently causes death from ascending urinary infection and decubitus ulcers In injuries below the first lumbar vertebra the cauda equina may be involved, with consequent paralysis of the feet loss of sphincter control and anesthesia of the genitals and buttocks

Sequellae of back injuries not evident at the time of the accident and *causing chronic disability may be posterior nerve root pain from pressure* at the intervertebral foraminae Kümmell's disease (post traumatic kyphosis) traumatic myositis and arthritis or the aggravation of a pre-existing chronic myositis or arthritis rupture of the intervertebral disc and spinal neurosis ("railway spine")

Treatment. The manner in which the patient is moved and treated immediately after the injury may have a decided effect upon the end result Persons in first aid stations policemen, and attendants in emergency rooms



Fig 77 Immobilization for Severe Fractures of Cervical Spine
For security the plaster must include at least the shoulders and chest, or may be extended to the pelvis

should be instructed in the proper handling of these cases Every patient whose back has been injured or who has been involved in a severe accident or has fallen from a considerable height should be treated temporarily as having a fracture of the spine He should be carried face downward and if it is necessary to turn him he should be rolled carefully to avoid further injury When the neck is injured the patient should be kept lying on this back using a small pillow to produce moderate hyperextension When the back is involved the patient should lie in the supine position upon a convex frame If the convex frame is not available boards should be placed crosswise beneath the mattress with the addition of a firm pillow under the back for maintaining moderate hyperextension of the spine

Treatment of fractures of the cervical vertebrae The patient should lie in the supine position with the neck kept hyperextended by placing a rolled blanket under the mattress at the level of the shoulders Treat all cases at first by continuous traction to the occiput and chin with a split loop of muslin bandage or with the standard traction apparatus known as a Glisson sling (See Traction, page 67) The head should not be lifted for drinking or when the bed clothes are changed

A minor fracture does not require traction, but should be immobilized for three months with a plaster of Paris collar maintaining hyperextension which should include the entire head neck and trunk Fractures of the odontoid process are serious, and almost always are followed by fibrous



Fig 78 Brace for Cervical Spine
To completely immobilize the neck a brace must extend from the occiput and chin to the pelvis

union a rigid support for at least 12 months is advisable An alternate form of immobilization is a cervical brace or molded leather collar which is made by orthopaedic bracemakers Support should be worn for from three to six months depending upon the individual case During the last few weeks the support is worn it should be removed daily for physiotherapy including exercises

Treat compression fractures with a Glisson sling using from two to five pounds of traction The patient should lie upon an air mattress with a small pillow placed under the neck and wrinkles in the draw-sheet should be prevented Apply plaster of Paris as soon as possible including the head neck and trunk the neck should be held moderately hyperextended in the collar

When there is a major fracture and the cord is involved the patient may

live only a short time For fracture-dislocation the most satisfactory form of treatment is continuous skeletal traction on the skull by means of Crutchfield tongs If progressive paralysis is caused by the increasing pressure of edema and hemorrhage spinal puncture may be helpful Although operations on such cases are serious the value of gentle open reduction and internal fixation has been proven

Treatment of fractures of the dorsal vertebrae When there is compression of the vertebral body with deformity the patient should lie on a convex frame or the part of the mattress under the affected portion of the spine

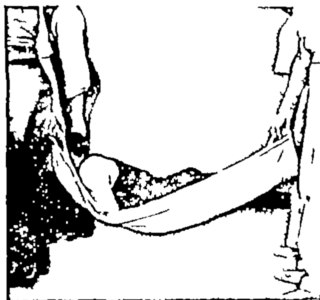


FIG 79 FIRST AID FOR INJURED BACKS

The initial care of back cases is extremely important The prone position should be used for transporting every patient who has sustained injuries of the back This position maintains the normal shape of the back and thus protects the vertebrae from further damage

may be raised with boards The pressure of hemorrhage on the cord should be relieved by lumbar puncture When there is little or no compression or a generalized compression without deformity keep the patient lying on his abdomen in a firm bed give heat massage and exercises daily, and encourage him to get out of bed after one month while wearing a light plaster of Paris jacket applied without hyperextending the spine Reduce compression fractures with wedging deformity as follows Place the patient face downward with only the hips and lower limbs resting on one table while the head and shoulders are supported on another table by assistants The sagging of the trunk between the tables produces sufficient hyperextension of the spine and thus reduction is accomplished by the fulcrum

of the posterior articulations The anterior common ligament of the spine is strong and prevents over hyperextension Occasionally gentle pressure over the kyphosis is necessary for impacted fractures As the normal space for the fractured vertebra is now restored the vertebral body will become calcified without deformity Do not move the patient from this position and apply a plaster of Paris jacket to maintain the hyperextension, including the neck and head for upper dorsal fractures

Directions for applying a plaster of Paris jacket To give adequate support the jacket must fit snugly over the upper portion of the sternum and the pubis anteriorly

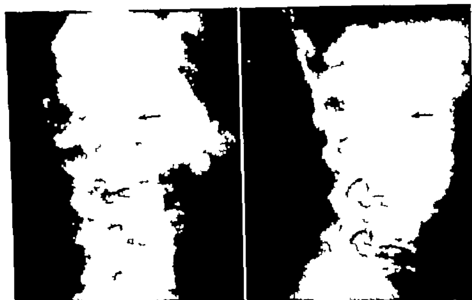


FIG 80 COMPRESSION FRACTURE OF FIRST LUMBAR VERTEBRA

In the first film the wedging effect is typical In the second film complete reduction of the deformity can be seen having been accomplished by hyperextension of the spine Treated by immobilization with a plaster jacket

and over the lower portion of the sacrum posteriorly Do not use more padding than necessary as a tight fit provides the best support without the friction caused by a loose jacket Cut a sheet of felt one-quarter inch thick six inches broad and long enough to encircle the highest part of the chest Cut another piece long enough to encircle the pelvis Use cool water which will permit time to rub and mold the plaster well during its application Make a reverse of two bandages to place around the pelvis and over this apply plaster bandages evenly rubbing well to prevent creases Then apply another reverse around the upper chest and continue with the plaster bandages molding the plaster snugly over the sternum as it hardens Reenforce by placing plaster reverses anteriorly posteriorly and laterally covering with additional plaster bandages As soon as the jacket has hardened cut out a large oval section over the abdomen This window provides room for better breathing and distension after eating Cut some of the plaster away from beneath the arms and from the groins so that the patient will not be restricted in sitting As a

considerable part of the jacket fits to the skin it will not mov or chafe and provides secure immobilization (See Use of plaster of Paris page 59)

Keep the patient who ha a compression fracture in bed for one month during which time he should be turned frequently Then prescribe exercises and encourage him to be up and about performing light exercises. In many cases the plaster can be removed in four months although in some instances a total of six months immobilization is necessary Not all compression fractures should be treated by hyperextension Generalized compression without wedging does not require hyperextension and such a

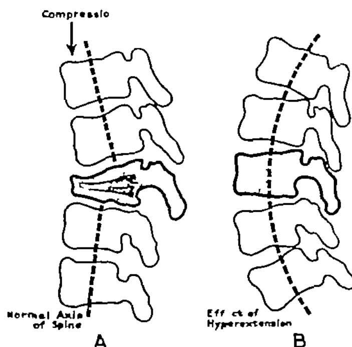


Fig 81 Mechanism of Compression Fracture

A. The typical fracture is produced by a jack knife injury B Hyperextension of the spine opens the space normally occupied by the collapsed vertebral body thus permitting the vertebra to heal without wedging deformity

position may increase the pressure on the spinal cord if the lamina is involved

When there are signs of severe cord damage which have not been relieved by the reduction of any existing deformity followed by application of the hyperextension jacket laminectomy should be considered In general this operation is indicated if improvement in the neurological signs has not occurred within the first two weeks although with flaccid paralysis such treatment is useless

Treatment of fractures of the lumbar vertebrae Compression of the ver

tebral body requires the same treatment as for fractures of the dorsal vertebrae Reduce the wedging deformity and apply a plaster jacket as described under fractures of the dorsal vertebrae Never apply plaster in the presence of ileus, but hyperextend the spine temporarily on a convex frame or in bed Ileus usually responds to enemas the administration of surgical pituitrin or prostigmin, and cascara, then the plaster jacket should be applied with a window cut out over the epigastrium

Keep the patient who has a compression fracture in bed for one month, having him turned frequently to avoid bed-sores and hypostatic pneumonia then prescribe exercises and encourage him to get out of bed and do light work The hyperextended position of the spine maintained by the

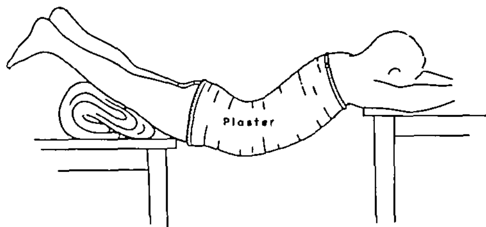


FIG 82 REDUCTION AND APPLICATION OF JACKET

A simple method of hyperextending the dorsal and lumbar spine for the reduction of compression fractures Note that the plaster jacket applied while in this position extends from the pubis below to the top of the sternum above and extends down over the sacrum

plaster jacket prevents pressure upon the vertebral body as all the weight of the trunk is borne posteriorly by the spinal joints

Laminectomy seldom is indicated for compression fractures of the lumbar vertebrae It is not considered for fractures with wedging deformity unless there is persistent spastic paralysis after reduction and application of the hyperextension jacket

Treatment of fractures of the spinous and transverse processes Fractures of the spinous or transverse processes in the lumbar spine require only rest in bed for four weeks during which period heat and massage are given Most of the single fractures which are not displaced unite without permanent complaints although many patients with fractures of several transverse processes from direct violence complain of chronic backache which is the result of accompanying muscular injury and fibrous union Such cases

must be treated by prolonged physiotherapy and exercises and finally it may be necessary to remove the ununited processes. When the articular processes are fractured or if there is a fracture-dislocation there may be serious cord damage. In such cases the hyperextension position may produce an increase in the injury to the cord, and continuous traction in bed is indicated. Later a plaster of Paris jacket should be applied without changing the position of the spine. If neurological symptoms persist gentle open reduction may be indicated.



FIG 83 FRACTURES OF THE TRANSVERSE PROCESSES

Produced indirectly by muscle pull. The patient was treated by rest on a firm mattress and daily physiotherapy for three weeks as for a sprained back. No support was used during convalescence.

Adjuvant care of cases having spinal injury. Nursing. The patient should lie upon an air mattress or fracture bed. Good nursing is important. The draw-sheet can be kept free from wrinkles by fastening it to each end of the mattress with elastics. The skin must be cleansed and powdered frequently and the linen changed often if there is incontinence. The patient should be turned once or twice daily and placed on a stretcher or carrier in the open air and sunshine.

Decubitus ulcer. It is important to prevent the formation of ulcers from continuous pressure and in anesthetic areas. The nurses should be instructed to be cautious when applying hot water bottles and therapeutic lamps over insensitive areas. If bed sores form the necrotic material

at the edges must be trimmed off and dry heat is applied The application of tannic acid also is recommended Pressure sores on the heels may be prevented by keeping a folded blanket under the Achilles tendons

Care of the bladder When there is retention of urine the policy of 'watchful waiting' is often sufficient, as many patients will finally void providing the distention is only moderate If the patient complains of severe pain Credéing of the bladder should be tried, this manual expression is carried out every four to six hours but must be employed before the distention becomes marked

Practically all urinary infections in cases with fracture of the spine are caused by repeated catheterization If catheterization is finally necessary, insert a retention catheter Have the pinch cock on the catheter released every five hours thus encouraging regularity in emptying the bladder Order daily irrigations through the catheter with warm boric acid solution and give hexamethylenamine with sodium acid phosphate routinely The operation of cystotomy is necessary if a marked cystitis develops

Ileus This condition may be serious Give enemas magnesium sulphate and ca cara and for more extreme cases order surgical pituitrin or prostigmin in divided doses

Constipation Secure daily evacuations Small amounts of croton oil are effective if milder purgatives fail

Follow-up treatment. It is a serious mistake to tell the patient in so many words that he has a fractured spine or a 'broken neck' as this may make him a confirmed psychological cripple Do not use a spinal brace If used early it does not immobilize satisfactorily if used after the removal of a plaster jacket the patient depends upon it too much and it is difficult to convince him to discard it It is much more satisfactory to use plaster of Paris throughout the period during which support is needed, the first jacket may be removed at the end of two months and a new jacket applied as the patient stands without hyperextending the back This jacket should be worn until no further support is necessary and during convalescence various exercises are carried out

Have the patient exercise the upper and lower extremities frequently and thoroughly during the entire period of recumbence thus avoiding much weakness from inactivity One of the most practical forms of exercise is carrying out the motions of swimming especially using the breast and crawl stokes while in the prone position After the period of recumbence the patient should do light work and gradually advance to heavy work

Most fractures of the vertebral bodies need support by a plaster jacket for from four to six months When the cord has been injured gentle exercises of the extremities should be given Tight muscles in the limbs should be stretched gently but firmly every day (See Physiotherapy page 81)

Contractures in the limbs must be prevented by using well padded splints and braces The muscles should be massaged with gentle upward stokes for flaccid paralysis but should not be excited by local treatment when there is spastic paralysis Electrotherapy may be given cautiously for the flaccid type of paralysis but stimulation should be avoided when there is spasticity Braces and local operations are necessary for weakness and permanent paralysis in the limbs Operative fixation of the affected portion of the spine may be necessary for persistent weakness or pain at the level of the fracture

Precautions. All persons whose backs have been injured or who have sustained multiple severe injuries as in automobile accidents should be transported face downward in order to prevent additional damage. Upon being placed in bed the spine should be hyperextended When the neck is injured it should always be kept immobilized and hyperextended by placing a small pillow or rolled towel behind it All fractures of the spine are so serious that an immediate consultation is advisable The treatment of fractures of the vertebrae requires as much individualization as that of any other major fracture and there is no satisfactory routine Hyperextension is not always indicated All compression fractures with wedging deformity should be reduced as soon as the general condition is favorable If ileus appears it should be controlled before plaster is applied. Spinal braces should be avoided and the routine use of plaster of Paris is advised for the immobilization of compression fractures The need of careful nursing should be emphasized

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CHAPTER X

PELVIC BONES

Fractures of the sacrum. *Etiology.* Although the sacrum and coccyx are a portion of the spine it is more convenient to consider them with the pelvic bones. Fractures of the sacrum may accompany severe fractures of the innominate bone. These injuries are caused by direct violence such as falling in a sitting position and kicks.

Examination. Pain is usually moderate most of it being caused by the accompanying injury to the overlying soft parts. Sitting stooping and coughing aggravate the pain. There may be symptoms from involvement of the sacral cord or nerves emerging at the level of the fracture such as lack of normal sphincter control and anesthesia of the genitals and gluteal region. Externally there may be ecchymosis. Internal examination by placing a finger in the rectum may reveal linear tenderness and when the fracture is complete there may be mobility and crepitus. In severe fractures with displacement the distal fragment usually is anterior. Minor fractures may not be detected without X ray examination.

Complications. In extreme cases especially when the other pelvic bones are fractured there may be damage to the pelvic viscerae.

Prognosis. These fractures unite in six weeks. Reduction of displacement often is difficult or impossible. Damage to the sacral nerves may be permanent with impairment of urinary control and sexual power.

Treatment. For linear fractures or when the fragments are in good position only rest in a soft bed is required. When there is displacement reduction of the fragments should be attempted by finger manipulation through the rectum. Later the application of heat and massage and adhesive strapping for weakness of the lower back are helpful.

Fractures of the coccyx. *Etiology.* Most of these fractures occur in women probably on account of the breadth of the female pelvis and are generally caused by falls in the sitting position. The line of fracture usually is transverse between the lower segments. Pain in and about the coccyx is known as coccygodynia. This symptom is not always the result of fracture as many neurasthenic women have coccygodynia following such minor injuries as sprains.

Examination. Any motions which involve the muscles of the pelvic floor such as stooping defecation and coughing cause severe pain. Examine the coccyx bimanually with one finger in the rectum. There is tenderness over the coccyx externally and internally and there may be

deformity abnormal mobility and crepitation Pain on movement between the sacrum and coccyx or between the segments of the coccyx may be due to sprain without fracture A routine X ray examination should be ordered after all injuries of the back and pelvis

Complications Neurasthenia and hysterical spine", with localized pain in the coccygeal region frequently occur after falls upon the buttocks In extreme cases the rectal wall may be injured

Prognosis It is impossible to foretell whether or not the case in question will be free from symptoms although recovery from the fracture is expected within six weeks Operation may be necessary

Treatment Correct displacement by pressure externally combined with pressure with a finger in the rectum The patient should rest in bed and apply hot compresses until acute symptoms have subsided Order a 25-per cent ichthyol suppository nightly Prevent constipation with mild laxatives Heat massage of the levator ani through the rectum and sitz baths are helpful Injections of small amounts of alcohol may be effective in relieving chronic pain If conservative measures fail removal of the lower fragment or of the entire coccyx usually will give relief Before considering operation however it is well to try the effect of adhesive strapping or a reenforced corset as low back strain and faulty posture often cause pain about the sacrum and coccyx

Fractures of the ilium, ischium and pubis *Etiology* The ischium is seldom broken Fractures of the iliac and pubic bones are caused by crushing injuries as automobile accidents and cave-ins at mines and construction work Fractures of the acetabulum are produced by falling in the standing position or by severe force directed to the side of the hip Less force is required to cause these fractures in women than in men on account of their smaller bones and broader pelves Fractures of the pelvis may be classified as follows A involving the pelvic ring (pubic bones) B not involving the pelvic ring (iliac bones and acetabulum) C a combination involving the pubic bones and the iliac or sacroiliac areas

Single fractures of the pelvic ring are the most common and are caused by direct external violence The fragments are not decidedly displaced and even when both pubic bones are fractured there is relatively little separation

Single fractures of the ilium and the acetabulum are caused by direct lateral violence The wing of the ilium may be broken by direct injury and in some instances there is comminution Fracture of the anterior superior spine of the ilium occurs rarely from extreme muscular exertion as jumping this is seen only in adolescents and actually is an epiphyseal separation Extreme antero-posterior force causes fractures of both

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pubic rami, combined with a break in the posterior portion of the pelvis as through the sacroiliac joint and is known as Malgaigne's fracture

Examination Do not move the patient for examination and avoid manipulation Minor fractures, especially those in the pubic ramus are accompanied by little pain, and as the patient lies in bed there may not be any signs of bone injury because the remainder of the pelvis is intact Walking is possible, although with pain in the perineum With severe fractures in the wing of the ilium often there is a large hematoma in the muscles The more severe fractures involving pubic bones or the acetabulum cause considerable pain and shock and these may be evidence of visceral damage Lateral compression over the hips usually causes severe pain and there may be abnormal mobility Rectal examination



Fig 84 Fracture of the Ilium
This injury causes relatively slight symptoms and treatment consists of rest in a soft bed for three weeks

should be performed routinely as in this way displacement of fragments often can be palpated Severe injuries are accompanied by shock and damage to the urethra and other viscerae are common It should be remembered that the urethra is in close contact with the pubic bones at the symphysis Blood appearing in the urinary meatus or hematuria signifies laceration of the membranous urethra or rupture of the bladder The patient should be catheterized carefully When the bladder is ruptured extraperitoneally there is a tumefaction in the suprapubic area caused by extravasation of urine or blood When intraperitoneal rupture occurs blood but no urine is obtained by catheterization and later signs of peritonitis develop X ray examination always should be made and if the general condition permits this should be done before the patient is

placed in bed if not the bedside apparatus should be used without moving the patient It is of the greatest importance to examine severe injuries of the pelvis carefully and immediate surgical consultation is advisable

Complications In severe cases in addition to the immediate shock and hemorrhage there may be laceration of the urethra or bladder, ileus, and laceration of the perineum or rectum There may be associated bony injuries as fracture of the lower lumbar vertebrae and fracture of the femur Later complications may include peritonitis thrombophlebitis from involvement of the pelvic vessels and edema of the lower limbs

Prognosis Single fractures require only rest for a few weeks and seldom cause permanent complaints In older persons however, the injury producing even a minor fracture may cause permanent pain and



FIG 85 MULTIPLE FRACTURES OF THE PELVIS
Fractures of the rami of both pubic bones produced by severe compression force Such an injury may involve the bladder or urethra Treated by rest in a soft bed

disability due to the aggravation of a pre-existing myositis or fasciitis In women multiple fractures in the pelvic ring may so alter the birth canal as to interfere with labor Penetrating fractures of the acetabulum usually cause permanent limitation of motion at the hip joint In severe pelvic fractures complications are common and cause a mortality rate which ranges from 12 per cent to 30 per cent Combined anterior and posterior fractures of the pelvis are serious and in addition to the probability of visceral damage there may be permanent deformity and disability on account of asymmetry and inequality in length of the limbs also involvement of the sacrosciatic plexus may occur

Treatment The proper treatment of pelvic fractures begins with careful transportation Upon reaching the hospital the patient should

have a careful examination and immediate attention Single fractures require only rest in bed for four weeks Treat fractures of the anterior superior spine of the ilium by rest in bed for four weeks keeping the hip flexed to relax the tensor fasciae femoris and sartorius muscles Treat fractures in the wing of the ilium by rest in bed with the application of heat and massage For penetrating fractures of the acetabulum make traction and abduct both thighs widely under anesthesia If this is successful *apply a double plaster spica to maintain wide abduction of the hips* If unsuccessful try forceful adduction Then apply plaster of

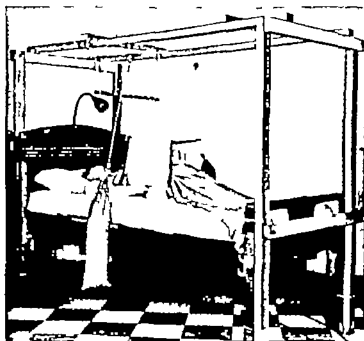


FIG 86 HAMMOCK FOR SEVERE PELVIC FRACTURES

This provides suspension and compression The sandbags hanging over the *sides of the bed balance the weight of the patient Adhesive traction may be added* to the lower extremities.

Paris for immobilization (See Directions for applying a double plaster spica for fractures of the hip page 216) As a last resort it may be necessary to use skeletal traction making a lateral pull on the greater trochanter combined with a length wise pull by Russell s traction or skeletal traction through the tibial tubercle (See Traction page 67)

With severe pelvic fractures treat the shock and watch for signs of visceral damage Visceral complications are emergencies and should be treated by the surgeon Treat ileus by giving enemas cascara three times daily and use surgical pituitrin or prostigmin cautiously For multiple fractures of the pelvis without spreading keep the patient in a flat bed

For multiple fractures with spreading add lateral compression by applying adhesive strapping or a many tailed binder and place the patient in a canvas sling which is suspended from a frame over the bed. Do not use



FIG 87 SEVERE INJURY OF THE PELVIS (MALGAIGNE FRACTURE)
Fractures of the pubic bones combined with dislocation at the sacroiliac joint. With such an injury involvement of the pelvic organs and of the sacrosciatic plexus is common



FIG 88 PENETRATING FRACTURE OF THE ACETABULUM (CENTRAL DISLOCATION)
Note the inward and upward displacement of the femur. Treatment indicated is manipulation under anesthesia followed by Russell's traction for eight weeks. The addition of lateral traction may be necessary

any form of compression or pelvic sling if the fragments are overlapping. When gross displacement of the fragments persists the method of Jahss is effective. This consists of applying plaster of Paris to both limbs and

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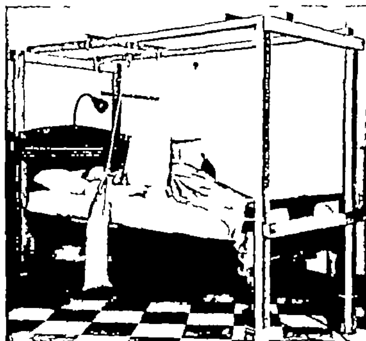


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CHAPTER XI

STERNUM AND RIBS

Fractures of the sternum. *Etiology* The sternum is seldom fractured as it is protected by the clavicles and ribs The typical fracture is transverse and occurs at the junction of the manubrium and gladiolus being due to direct force as in automobile accidents A jack knife injury with compression fracture of a vertebra sometimes also causes fracture of the sternum The extent of damage to the sternum and intrathoracic viscera depends upon the severity of the causative force Intrathoracic damage may be so great as to cause immediate death The lack of deformity is not dependable as indicating the extent of damage

Examination Incomplete or impacted fractures cause relatively little pain and may be detected only by the routine use of X rays

When the fracture is complete the patient has severe pain which is aggravated by forced inspirations and coughing The shoulders are stooped and if the fragments overlap there is visible deformity There is localized tenderness and may be crepitation upon deep inspiration although the patient breathes shallowly X ray examination always should be ordered the lateral view being especially important

Complications Severe fractures of the sternum are often accompanied by intrathoracic injury and fractures of the ribs and clavicle There may be mediastinal hemorrhage and injury to the pleura

Prognosis Fractures without displacement unite within six weeks Patients with extreme displacement may die from complications

Treatment Apply adhesive strapping for simple linear fractures When there is displacement keep the patient lying in the supine position on a bed flattened with boards placed crosswise under the mattress and place a small sandbag under the dorsal spine If rest in this position fails to reduce the fracture manipulate as follows

Allow the shoulders and head to droop over the edge of the table and make traction on the arms held externally rotated above the head and countertraction upon the lower portion of the thorax After the fracture has been reduced place the patient in bed with a small sandbag between the shoulders

Fractures of the ribs. *Etiology* These are common injuries and are more often multiple than single They occur almost always in adults although greenstick fractures are occasionally seen in children The middle ribs usually are involved fractures in the upper ribs being rare

either spreading or compressing the pelvis by adjusting the three turn buckles which are fastened crosswise in the plaster

Follow-up Treatment After the time required for union the patient should remain in bed for about two weeks longer in order to sit up and exercise For multiple fracture cases crutches are necessary for an additional period of several weeks During convalescence a tight binder or low back brace is useful for weakness of the pelvic joints and the lower back The stock sacroiliac belts are poor substitutes for low back braces made to measurement by an orthopaedic brace-maker

Precautions Consider every severe injury in the region of the pelvis as a surgical emergency on account of the possibility of visceral damage. Watch for signs of progressive shock which usually indicate rupture of a viscus Also watch for bleeding from the urethra vagina and rectum Distension above the pubis signifies rupture of the bladder Multiple fractures of the pelvis often cause permanent deformity and shortening of the lower limb and should have competent attention early Elevate and compress the pelvic bones in a hammock when the fractures are linear or are spreading but do not use lateral compression for multiple fractures when there is inward displacement and overlapping of the fragments

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Fracture or separation of a costal cartilage cannot be demonstrated on the X ray film, and diagnosis must be made by physical signs alone

Complications In severe cases the chest wall is decidedly contused and may be lacerated Multiple fractures often are accompanied by emphysema of the subcutaneous tissues and there is shock Puncture of the lung by depressed fragments causes hemothorax or pneumothorax, which may be followed by empyema Hypostatic pneumonia frequently

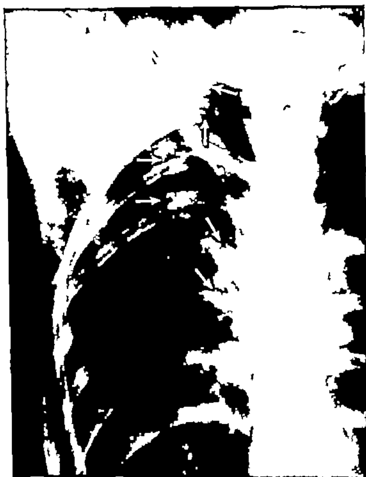


FIG 90 MULTIPLE FRACTURES OF RIBS
Note also the accompanying fracture of the clavicle There were pulmonary complications

develops in the aged and in alcoholics Overlapping of fragments with excess callus formation may be followed by persistent intercostal neuritis from constriction of the nerve

Prognosis Simple fractures without complications unite readily and do not cause permanent trouble Overlapping of the fragments is not serious Emphysema and dry pleurisy disappear in about ten days Severe multiple injuries of the chest cause decided shock There is a

because they are short and protected by the clavicle, and on account of flexibility the floating ribs seldom are broken The number of ribs involved the extent of damage and the amount of displacement depend upon the severity of the accident Comminuted and compound fractures are usually multiple from collisions and war wounds Occasionally the ribs are fractured by indirect violence as severe coughing or twisting Severe blows to the chest sometimes produce fracture or separation of the costal cartilages



Fig 89 Lateral View Fracture of the Sternum
The line of fracture often is not detected by X ray examination if only an anteroposterior view is obtained

Examination The patient complains of severe pain in the chest, with aggravation by deep breathing and coughing There is local swelling and tenderness and pain when the chest is compressed Multiple fractures produce shock and dyspnoea and intrathoracic damage with these may be so severe as to cause death When crepitus cannot be detected by palpation sometimes it may be heard with the stethescope X ray examination should be requested after every injury which has caused severe pain on deep inspiration Occasionally a linear fracture without displacement is not apparent in the film and under such circumstances the diagnosis of fracture is not a certainty until callus is seen in a later film or is palpable

relieved by aspiration of the air When there is blood in the pleural cavity it should be aspirated after the third day at which time bleeding has stopped If empyema occurs it must be treated surgically Treat shock by injections of morphine the application of external heat and infusions Lacerated wounds of the chest wall, often with compound fracture require early debridement as in other fractures When there are multiple displaced fractures compression of the chest increases the displacement in such instances the patient should be kept in bed, in the sitting position if most comfortable without adhesive strapping Open reduction is occasionally necessary and after exposure the rib may be

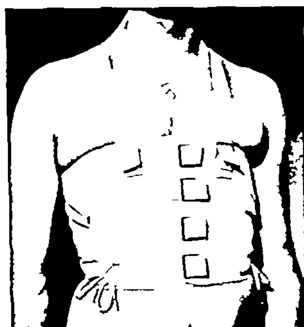


Fig 92 Chest Belt for Fractures of Ribs

This is made of light canvas and is more comfortable and restricts movements of the chest more effectually than adhesive plaster strapping It is especially useful for obese persons and when the skin does not tolerate adhesive plaster

grasped with a towel clip Older persons should be kept in the sitting position out of bed and may require stimulants Patients addicted to chronic alcoholism need liquor regularly

Follow up treatment Continue the strapping for four weeks reenforcing it or changing it every few days Injuries of costal cartilages require similar support for six weeks and if pain or snapping persists relief can be obtained only by removing the ununited portion of cartilage Persistent intercostal neuritis can be relieved by the injection of a small amount of alcohol along the lower border of the rib No patient should return to heavy work until there is evidence of union by the absence of crepitation and pain on deep breathing

high mortality with multiple fractures in alcoholics and old persons Persistent dyspnoea and cyanosis are unfavorable signs and when there are crushing injuries with intrathoracic damage the outlook is doubtful

Treatment For single fractures or multiple fractures without displacement or complications the treatment consists of restricting the respiratory excursions and thus partially immobilizing the fragments. Shave the hairs off the chest and in women have the nurse elevate the breast and protect the nipple with gauze Wash the skin with warm water and soap and then paint the chest with compound tincture of benzoin Cut several strips of two-inch adhesive preferably moleskin which strips are long enough to encircle two-thirds of the chest Fasten the adhesive

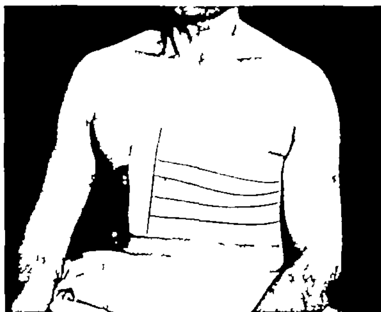


Fig 91 Adhesive Plaster Strapping for Fractures of Ribs
The adhesive plaster extends two-thirds of the distance around the chest

plaster while the patient holds the breath after expiration placing the first strip around the lower portion of the chest and overlap one-half the width of the strips as they are applied from below upward Treat fractures or separations of the costal cartilages similarly It is useless to apply adhesive plaster over fractures of the upper ribs although adhesive strapping around the lower chest may give considerable relief In fat persons whose skin is sensitive and in folds adhesive plaster is unsatisfactory, therefore the chest should not be strapped but should be encircled with one or two broad ACE bandages, or a canvas binder way be used. If there is a dry persistent cough from pleural irritation a sedative cough mixture is useful Emphysema usually does not require treatment, as it disappears spontaneously in a few days. Pneumothorax with severe dyspnoea can be

relieved by aspiration of the air When there is blood in the pleural cavity it should be aspirated after the third day at which time bleeding has stopped If empyema occurs it must be treated surgically Treat shock by injections of morphine the application of external heat and infusions Lacerated wounds of the chest wall often with compound fracture require early debridement as in other fractures When there are multiple displaced fractures compression of the chest increases the displacement, in such instances the patient should be kept in bed in the sitting position if most comfortable without adhesive strapping Open reduction is occasionally necessary, and after exposure the rib may be

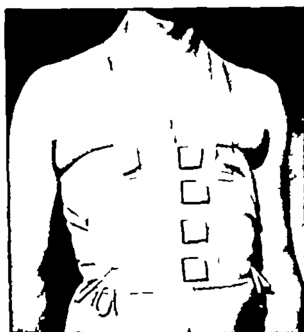


FIG 92 CHEST BELT FOR FRACTURES OF RIBS

This is made of light canvas and is more comfortable and restricts movements of the chest more effectually than adhesive plaster strapping It is especially useful for obese persons and when the skin does not tolerate adhesive plaster

grasped with a towel clip Older persons should be kept in the sitting position out of bed and may require stimulants Patients addicted to chronic alcoholism need liquor regularly

Follow-up treatment Continue the strapping for four weeks reenforcing it or changing it every few days Injuries of costal cartilages require similar support for six weeks and if pain or snapping persists relief can be obtained only by removing the ununited portion of cartilage Persistent intercostal neuritis can be relieved by the injection of a small amount of alcohol along the lower border of the rib No patient should return to heavy work until there is evidence of union by the absence of crepitation and pain on deep breathing

high mortality with multiple fractures in alcoholics and old persons Persistent dyspnoea and cyanosis are unfavorable signs and when there are crushing injuries with intrathoracic damage the outlook is doubtful

Treatment For single fractures or multiple fractures without displacement or complications the treatment consists of restricting the respiratory excursions and thus partially immobilizing the fragments Shave the hairs off the chest and in women have the nurse elevate the breast and protect the nipple with gauze Wash the skin with warm water and soap and then paint the chest with compound tincture of benzoin Cut several strips of two-inch adhesive preferably moleskin which strips are long enough to encircle two-thirds of the chest Fasten the adhesive

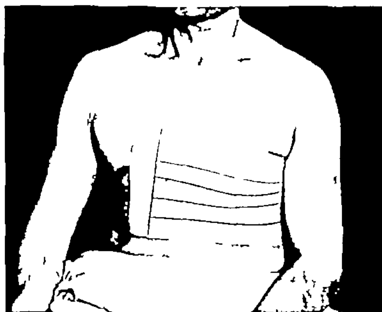


FIG 91 ADHESIVE PLASTER STRAPPING FOR FRACTURES OF RIBS
The adhesive plaster extends two-thirds of the distance around the chest

plaster while the patient holds the breath after expiration placing the first strip around the lower portion of the chest and overlap one-half the width of the strips as they are applied from below upward. Treat fractures or separations of the costal cartilages similarly It is useless to apply adhesive plaster over fractures of the upper ribs although adhesive strapping around the lower chest may give considerable relief In fat persons whose skin is sensitive and in folds adhesive plaster is unsatisfactory therefore the chest should not be strapped but should be encircled with one or two broad ACE bandages or a canvas binder way be used If there is a dry persistent cough from pleural irritation a sedative cough mixture is useful Emphysema usually does not require treatment as it disappears spontaneously in a few days Pneumothorax with severe dyspnoea can be

CHAPTER XII

CLAVICLE AND SCAPULA

Fractures of the clavicle. *Etiology.* The clavicle is a slender, compact bone with two curves, which acts as a prop to hold the point of the shoulder away from the trunk. This is one of the commonest locations for fracture, especially in children. The usual cause is a fall on the outstretched hand, the force being transmitted upward and producing a break at the junction of the middle and outer thirds of the bone where it is thinnest. This fracture in children may be of the greenstick variety. In adults the fracture is complete and the fragments are ordinarily displaced, although when the line of fracture is near the acromion process there is seldom marked displacement. Many of these fractures in adults are caused by direct violence, which may produce comminution.

Examination. In children with a greenstick fracture there is only moderate pain; there is moderate angulation deformity with tenderness but without crepitus and no abnormal mobility. The typical complete fracture causes severe pain which is aggravated by movements of the shoulder; the shoulder droops forward and the elbow must be supported by the hand of the unaffected side. As the propping support of the shoulder is lost, the distal fragment is displaced downward and inward on account of the weight of the arm and the pull of the pectoralis major; the proximal fragment is drawn upward by the contraction of the sternocleidomastoid. Other signs are swelling, extreme tenderness and decided crepitus. The clavicle is so superficial that the prominence of the inner fragment can be palpated easily. Fractures in the outer end of the clavicle near the acromion process present a different picture; often there is no deformity and crepitus, diagnosis being made by the history, pain on movements of the shoulder and pronounced tenderness. X-ray examination, which should be ordered routinely, is often unnecessary for diagnosis but may be important in determining the treatment. Greenstick fractures may escape recognition except by X-ray examination.

Complications. Damage to the subclavian vessels or brachial plexus occurs rarely. A slight deformity is common.

Prognosis. Almost all of these fractures unite readily and firmly regardless of the insecure forms of immobilization which may be used. Overriding is common, but does not cause impaired function. There is frequently a slight deformity from overlapping, but after a few months this may be scarcely apparent as the edges of the fragments become

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in adults unite within eight weeks Permanent complaints or disability are uncommon Non union is rare

Treatment As it is not possible to completely reduce most of these fractures by manipulation the purpose of any form of treatment is to maintain as much reduction as possible The distal or outer fragment must be placed and held as closely as possible to the proximal fragment The number of dressings and splints which have been devised are evidence of the difficulties of adequate immobilization



FIG 95 REDUCTION OF FRACTURES OF THE CLAVICLE
The patient sits on a stool and the operator makes firm traction upward and backward on the shoulders with his knee acting as a fulcrum

In infants and children make firm pressure to correct angulation Have an assistant to hold the shoulders upward and backward while a posterior figure-of-eight bandage is applied and add a bandage sling from the neck to the wrist Continue re-bandaging for four weeks checking the position by X ray examination

In adolescent girls and women in whom a slight deformity is very objectionable accurate alinement is important The physician should stand behind the patient who is seated on a stool and pull the shoulders upward and backward placing his knee between the scapulae for leverage

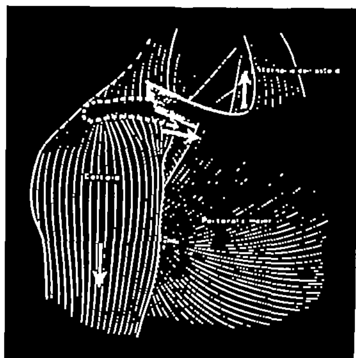


FIG 93 TYPICAL FRACTURE OF THE CLAVICLE
Arrows indicate the displacing effect of the muscles



FIG 94 AVERAGE FRACTURE OF THE CLAVICLE
There is also a fracture of the acromion process Satisfactory result after dressing with a posterior figure-of-eight bandage and a sling

rounded and enveloped in the spindle-shaped mass of callus A majority of the fractures of the clavicle in children unite within four weeks and those

In men, pull the shoulders upward and backward, and use the adhesive strapping and sling described above for eight weeks *In comminuted cases* it may be necessary to treat the patient in bed in order to secure the best positions and maximum immobilization The T-splint combined with a posterior figure-of-eight bandage is an alternate method During the last two weeks light exercises should be encouraged but the patient must not engage in athletics or heavy work until there is no longer pain on moving the shoulder and sensitiveness of the callus has disappeared X ray examination should be ordered during the course of immobilization and later to determine when the fragments have become firmly united

Follow up treatment If there is a permanent deformity caused by over

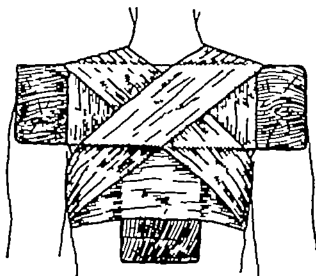


FIG 97 T-SPLINT FOR FRACTURES OF THE CLAVICLE

This splint can be made by nailing two pieces of wood together Note that the ends of the splint extend to the tips of the shoulders The perpendicular portion is fastened to the patient's back with broad strips of adhesive plaster Then the axillae are padded for the posterior figure-of-eight bandage and a sling is used on the affected side This *dressing is clumsy but effective*

lapping or angulation the projecting portion can be removed by operation Comminuted fractures in older persons often require prolonged immobilization

Precautions Explain the difficulties of reduction and immobilization of this fracture to the patient and thus avoid dissatisfaction if finally there is a noticeable deformity Use sufficient padding in the axillae to prevent swelling of the arms Always order X ray examination during the course of treatment In females insist upon recumbency for the best result Young persons should not engage in violent sports until the next season

Fractures of the scapula. *Etiology* Fractures of the scapula are un

if necessary Then while an assistant hold the shoulders in this position with the distal fragment raised upward and backward to meet the proximal fragment apply adhesive plaster strapping according to Hawley's method In individuals whose skin is tender paint the area to be covered with compound tincture of benzoin Fasten a double thickness strip of adhesive plaster three inches wide to the front and upper portion of the arm, pass it around the outer side of the arm and back of the chest to end over the front of the chest on the opposite side Then fasten another double-thickness strip in the same manner partly overlapping the first strip Next fasten a third double-thickness strip over the shoulder to hold the

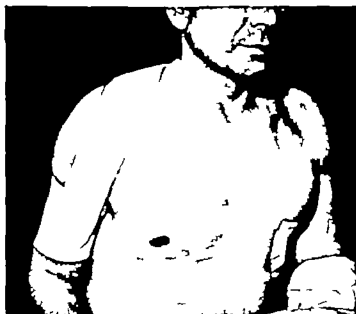


FIG 96. HAWLEY'S ADHESIVE STRAPPING FOR CLAVICLE FRACTURES
The shoulders are held backward and upward while double-thickness adhesive strips are passed around from the inner surface of the arm over the back and around the chest on the opposite side Finally an upper strip is applied to prevent the first strips from slipping This method is satisfactory for a majority of cases

fragments and other adhesive strips more securely Finally apply a bandage sling from the neck to the wrist If an X ray examination shows that the position is unsatisfactory remove the adhesive plaster as the treatment must be carried out in the recumbent position. Have the patient lie upon a firm bed, laying boards crosswise underneath the mattress to prevent sagging and place a narrow sandbag between the scapulae A small sandbag also should be placed anteriorly over the tip of each shoulder and a bandage sling is fastened from the neck to the wrist The patient must lie quietly for four weeks after which adhesive plaster should be used for four weeks longer



FIG 99 FRACTURE THROUGH THE BODY OF THE SCAPULA
Treated by adhesive strapping with a sling



FIG 99a FRACTURE OF ACROMION PROCESS OF SCAPULA

Displacement of the acromion unless corrected results in permanent restriction of shoulder movements especially abduction The first film shows the *rotation* and downward displacement which occurs with complete fractures The second film shows complete correction by abduction of the arm and application of a plaster of Paris spica in the salute position

common as this bone is well protected by muscles and by its free movements Major fractures occur in severe accidents and often are accompanied by other injuries as fractures of the ribs and humerus Many of the minor fractures are caused by indirect violence as blows on the side of the shoulder When the fracture extends through the body it is often comminuted and may involve also the neck of the bone The glenoid may be involved by violent force applied externally to the shoulder An avulsion fracture of the glenoid may accompany dislocation of the humerus, the bony attachment of the capsular ligament being torn off The acro-



FIG 98 MALUNION OF CLAVICLE WITH EXCESS CALLUS FORMATION
This extent of displacement produces external deformity and a drooping shoulder

mion process may be fractured by blows on the side of the shoulder or by falling objects and the coracoid process is occasionally broken

Examination All movements of the shoulder and lateral compression are painful and limited When the body of the scapula is broken there is pronounced swelling and a large hematoma can be palpated posteriorly With fractures of the acromion and coracoid processes there is crepitus and localized tenderness with increased pain on movements of the shoulder X ray examination should be made in the anteroposterior plane and laterally through the axilla while the arm is held in the vertical position

Prognosis Uncomplicated fractures in the body of the scapula unite in six weeks and usually do not cause permanent disability although associated conditions may be serious Function may be impaired after frac

CHAPTER XIII

HUMERUS

Fractures of the humerus are considered under the following classification (1) Separation of the upper epiphysis (2) fractures of the tuberosities, (3) fractures in the neck of the humerus, (4) fracture-dislocations at the shoulder (5) fractures in the shaft

Separation of the upper epiphysis. *Etiology* The upper epiphysis of the humerus does not unite with the shaft until the twenty first year and on this account separation may occur during adolescence In most instances the condition occurs in boys and is caused by direct violence to the shoulder from falls and football

Examination When the epiphysis is separated but not displaced there is swelling and moderate tenderness without deformity Rotation of the arm causes pain although no abnormal mobility may be found upon palpation in the axilla Displacement of the epiphysis causes complete disability and severer symptoms Upon palpation there is abnormal mobility the head does not rotate with the shaft, and a muffled crepitus or peculiar slipping sensation similar to that caused by a dislocation can be detected The X ray films may not show a distinct change when the epiphysis is only separated and not displaced

Prognosis There will be deformity and limited motion if decided displacement is not corrected Such injuries to the epiphysis may cause disturbance of growth in the arm The epiphysis becomes firmly re-attached within six weeks

Treatment When the epiphysis is not displaced immobilize the shoulder with a Velpeau dressing When there is marked displacement give anesthesia and make traction upon the arm as it is held in slight flexion and abduction meanwhile pressing directly against the epiphysis in order to approximate it with the position of the shaft After reduction, immobilize the shoulder in moderate abduction and slight flexion in a plaster spica for six weeks (See Directions for applying a plaster spica of the shoulder page 139) Operation is necessary if manipulation fails to reduce gross displacement

Fractures of the greater tuberosity *Etiology* These fractures are caused by either direct or indirect violence In the direct form which is produced by a blow or fall upon the side of the shoulder the fragment is large comminuted and usually not markedly displaced In the indirect form which is caused by sudden tension on the supraspinatus tendon while

tures of the glenoid and after displaced fractures of the acromion or coracoid process

Treatment For fractures through the body of the scapula, with which there usually is no gross displacement apply a Velpeau dressing with the shoulder held back For linear fractures of the glenoid and of the coracoid process apply a sling and encourage gentle movements With displaced fractures through the neck of the scapula treat the patient in bed by traction on the abducted arm Give treatment for simple fractures of the acromion process as for sprains at the acromioclavicular joint by strapping with a pad and adhesive plaster combined with a sling If the acromion fragment is displaced downward raise the arm and apply a plaster of Paris spica maintaining the salute position, this position corrects the displacement and ensures a good functional result (See Directions for applying a plaster of Paris spica page 139)

Follow-up treatment Patients with linear fractures in good position should avoid heavy exercising and working for eight weeks, although motions in the wrist and hand should be continued during this entire period For fractures in the body of the scapula with an extensive hematoma order the early application of heat and massage Continue the traction on fractures of the neck of the scapula for six weeks Immobilize fractures of the acromion or coracoid process for six weeks, give heat and massage and encourage active movements especially swinging the arm in circumduction and reaching upward (See Physiotherapy and motions page 81)

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count of adhesions and contracture in the capsular ligaments. Large, unreduced fractures of the greater tuberosity cause chronic pain and limited abduction because the fragment blocks against the acromion process. If avulsion fractures are not recognized or are not treated properly, there will be permanent disability because the patient cannot voluntarily abduct the shoulder.

Treatment. When there is no displacement simply use a sling for four weeks, give heat and massage and encourage graduated movements. When there is wide separation apply a plaster of Paris spica to immobilize the shoulder in the position of right angle abduction and external rotation for six weeks. This position relaxes the pull of the supraspinatus and infra-



FIG. 102. FRACTURE OF THE GREATER TUBEROSITY.

Same fracture as in preceding illustration after open reduction and immobilization in the abducted position. The function four months after operation was practically normal.

spinatus muscles which are inserted into the tuberosity and brings the shaft upward to meet the unmanageable fragment. (See Directions for applying a plaster spica of the shoulder, page 139.) If the position of abduction does not correct the displacement it will be necessary to operate and suture the tuberosity with silk or wire. When a displaced fracture of the tuberosity occurs with dislocations at the shoulder the arm should be immobilized in moderate abduction and rotation by means of a plaster spica. Insist that the patient use the wrist and hand during the entire period of immobilization and later the shoulder should be exercised by swinging the arm in circumduction and reaching upward. (See Physiotherapy and motions, page 81.)

Fractures of the lesser tuberosity are seen most often with comminuted

it is taut in abducting the shoulder, there is an avulsion or sprain fracture In this form the fragment is small and in many instances is widely separated This fracture may occur with a fracture in the neck of the humerus or a dislocation at the shoulder joint

Examination Pain is increased by attempts to raise the arm There is local tenderness and if the fragment is free there is crepitus on passively

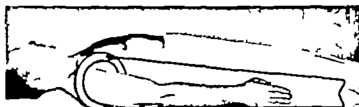


Fig 100 Murray-Jones Traction Splint
This is useful for emergency traction and transportation of fractures in the shaft of the humerus The joints at the ring permit easy application of the splint



Fig 101 Fracture of the Greater Tuberosity
The tuberosity is displaced by the pull of the supraspinatus tendon This condition cannot be treated conservatively

rotating the arm In many instances this condition is diagnosed only by X ray examination In addition to an anteroposterior film an exposure should be made with the arm externally rotated in order to show a better projection of the tuberosity

Prognosis Every severe injury of the shoulder even with a minor fracture may produce permanent limitation of motion and pain on ac-

little external deformity, being hidden by the musculature of the shoulder and by the swelling In some instances impacted fractures are diagnosed only by X ray examination, as they may not cause severe pain or complete loss of function If there is no impaction movements of the head of the humerus can be palpated during rotation of the arm Fractures in the neck of the humerus should be differentiated from dislocations at the shoulder joint by the abnormal mobility, severe tenderness and crepitus X ray examination is important, to confirm the diagnosis of fracture and to show its exact nature Exposures should be made in the lateral as well as in the anteroposterior direction



FIG 104 ANTEROPOSTERIOR VIEW FRACTURE IN NECK OF HUMERUS
Apparently there is no other displacement excepting adduction angulation

Prognosis Most fractures in the neck of the humerus unite in six weeks With impacted fractures there is only partial disability and recovery is rapid if immobilization is avoided Immobilization in abduction by means of a plaster spica produces good functional results in severe cases Limited motion in most cases is due to contracture of the joint capsule and not to displacement of the fragments It is surprising to see the satisfactory results of early and persistent exercises even when there is internal deformity

Treatment Do not immobilize impacted or comminuted fractures, simply apply a sling and instruct the patient to use the hand in light occu

fractures of the neck of the humerus, and with dislocations The lesser tuberosity may be torn off by the pull of the subscapularis muscle Treatment is for the associated injury

Fractures in the neck of the humerus. *Etiology* Although it has been customary to classify these fractures as being located either in the anatomical or surgical neck of the bone, such a classification has no practical value. Actually the line of fracture frequently extends through both the anatomical and surgical necks Fractures in the neck of the humerus are caused



FIG 103 ABDUCTION FRACTURE IN THE NECK OF THE HUMERUS
There also is a fracture of the greater tuberosity The abduction angulation must be reduced by manual traction combined with adduction of the arm.

by falls on the outstretched hand and by blows on the side of the shoulder A practical classification of these injuries is (1) comminuted fractures (2) adduction fractures (3) abduction fractures In the aged when the cancellous portion of the bone is brittle impacted fractures are common There may be accompanying fractures of the tuberosities In rare instances a fracture-dislocation occurs being a combination of fracture through the neck and dislocation of the head

Examination These injuries cause pain and loss of shoulder function with ecchymosis, tenderness and often crepitus Angulation produces

pations about the home and to exercise the arm by easy relaxed movements and reaching upward Also apply heat and massage to hasten the absorption of hemorrhage

When the fragments are not impacted and there is decided angulation deformity must be corrected for maximum function This is accomplished by bringing the distal or movable fragment to meet the proximal or immovable fragment Usually no anesthesia is necessary for correction of angulation unless the fragments are impacted For fractures in which the shaft is abducted the surgeon should place his fist in the patient s axilla and produce moderate traction as the arm is carried to the side of the chest For adduction fractures the arm should be carried outward from the chest as moderate traction is made

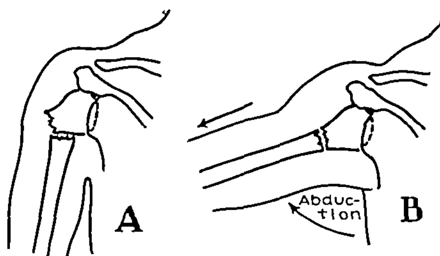


FIG 107 ADDUCTION TYPE OF FRACTURE IN NECK OF HUMERUS
A abduction of the proximal fragment caused by the pull of the supraspinatus B reduction is accomplished by traction and abduction placing the movable fragment in apposition to the immovable fragment

In children and younger adults immobilize for six weeks with a plaster of Paris spica, maintaining abduction and external rotation in the salute position before applying the plaster the best angle of abduction should be checked by portable X ray examination or fluoroscope (See Use of plaster of Paris page 59) An alternate method is the 'hanging cast ' especially useful if the abduction position causes angulation of the fragments

Directions for applying a plaster of Paris spica Seat the patient on a stool with the arm supported in the required amount of abduction and flexed forward in the salute position by an assistant Cover the chest and the entire upper extremity with stockinet Place ½ inch felt padding around the pelvis and under the elbow and wrist Apply plaster of Paris bandages snugly to the chest and extending down to the pelvis Reenforce with strips of plaster bandage across the shoulder and



Fig 105 Lateral View of Preceding Fracture
This demonstrates decided anterior angulation not apparent in the anteroposterior view



Fig 106 Reduction of Preceding Fracture
After traction and abduction

under complete general anesthesia, using abduction combined with upward traction on the arm in the perpendicular plane, thus carrying the shaft away from the dislocated head Then it may be possible to press the head into its place while the arm is held up in this position Open reduction is indicated if manipulation fails In poor operative risks the best form of treatment is early exercises, regardless of the X ray appearance, many cases obtain a fairly good functional result Excision of the dislocated

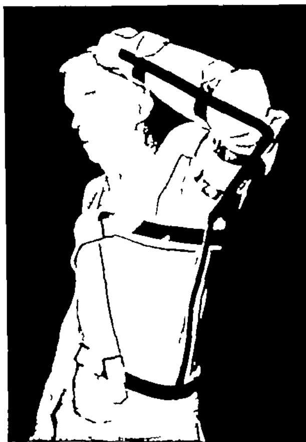


FIG 100 ABDUCTION BRACE FOR THE SHOULDER

So-called aeroplane splint, useful in treatment of fractures of acromion process and of greater tuberosity This brace also may be used for certain fractures in the neck of the humerus

head is not advisable as the functional results after this operation are poor on account of a flail joint

Follow-up treatment Encourage the patient to exercise frequently commencing as soon as possible after the injury Order X ray examinations as a check on the position of the fragments during convalescence Swinging the shoulder in circumduction and backward and forward prevents adhesions and contractures of the shoulder joint capsule Reaching

anteriorly and posteriorly where there is the greatest strain rubbing the plaster constantly Then apply plaster to the elbow forearm and wrist but not extending further down than the knuckles Strengthen the plaster spica by fastening a plaster rope" or a stick of wood in it extending from the elbow to the lower border of the chest Then cut a 'window in the plaster over the abdomen for distension and free breathing and finally roll the stockinet over the edges of the plaster and fasten it with a few additional turns of plaster bandage

In older persons when the fragments are not impacted apply a Caldwell hanging cast This is an extra heavy circular plaster dressing which extends from the axilla to the knuckles with the elbow held at a right angle

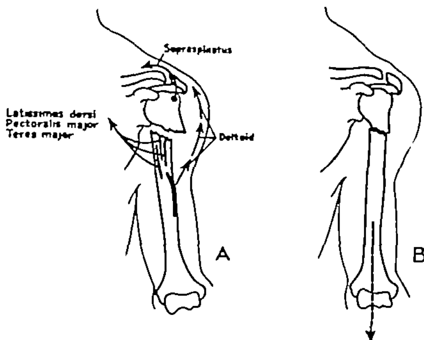


Fig 108. Typical Fracture in Neck of Humerus
A effect of muscles in displacing the fragments B satisfactory alinement produced by traction effect of the cast

The weight of the plaster produces enough traction to prevent overriding and angulation of the fragments yet the patient can exercise the limb immediately by relaxed movements, and thus prevents muscular atrophy and subsequent limitation of motion in the shoulder The author has found the hanging cast unnecessary for most older patients, and simply applies a sling of bandage, the exercises which are encouraged do not interfere with union Immobilization of the arm especially by bandaging it to the chest, should be avoided for best functional results

Fracture-dislocations at the shoulder are severe injuries often causing pressure on the brachial plexus and are difficult to treat Manipulate

verse to a spiral extending through nearly the entire shaft The type of break depends upon the nature of the force causing it direct injuries producing transverse or comminuted fractures and indirect injuries producing oblique or spiral fractures Severe compound fractures are common in war The close relation of the musculospiral nerve and the brachial artery to the shaft of the humerus should be remembered

Examination The usual findings are pain deformity, local tenderness abnormal mobility and crepitus In children the fragments seldom are separated In adults the relative position of the fragments depends upon the location of the fracture and the resulting muscular pull In the upper third of the shaft when the fracture is above the insertion of the deltoid

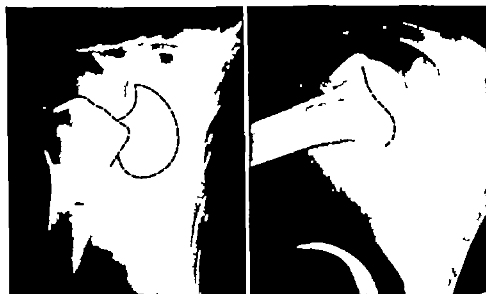


FIG 111 FRACTURE DISLOCATION OF THE SHOULDER
Manipulation was unsuccessful Before and after open reduction Union with good functional result although movements at the shoulder joint were decidedly restricted

the proximal fragment is held adducted by the latissimus dorsi and pectoralis major muscles which are attached to it When the fracture is below the deltoid insertion the proximal fragment is abducted by the deltoid and overriding by the lower fragment is caused by pull of the biceps and triceps In the lower third there is a tendency for the distal fragment to be displaced anteriorly by the weight of the forearm X ray examination should be made in more than one plane and should be ordered after every injury in which there is doubt as to the presence of fracture Much of the displacement of the fragments depends upon the position of the arm at the time of the examination

Complications Although frequent injury of the musculospiral nerve

upward with a loop of bandage over a door and "caterpillar" exercises also are helpful (See Physiotherapy and motions page 81)

Precautions When the adduction position is necessary avoid the Velpeau bandage using the hanging cast with active movements in order to secure the best function Insist that the patient use his hand in order to prevent stiffness Never break up impaction in the aged, unless there is extreme displacement Do not immobilize impacted fractures as only a



FIG 110 FOLLOW-UP TREATMENT
Simple effective exercise for restoring function in the shoulder This combines active passive and resistive motions

sling and exercising are necessary Never give passive motions during convalescence on account of the liability of disturbing union.

Fractures in the shaft of the humerus. *Etiology* The shaft of the humerus extends from the surgical neck to the condyles Fractures in the shaft occur at all ages even at birth Direct violence is the usual cause although torsion and even muscle action alone occasionally produce complete fractures All forms of fracture occur here varying from the trans



Fig 113 Birth Fracture of Humerus
It is unusual to find decided displacement of the fragments in infants and children



Fig 114 Sugar Tong Plaster Splint
A wet strip of plaster is placed directly over the skin surface and a gauze bandage is applied immediately This splint is satisfactory for fractures in the lower shaft of the humerus without displacement but does not control severe fractures

would be expected on account of its close contact with the humerus it is seldom involved The nerve may be damaged by the direct force causing the fracture or by pressure of the fragments, later it may be constricted by callus Signs of involvement vary from sensory changes to wrist drop and inability to extend the thumb and fingers The brachial artery may be lacerated or pressed upon by the fragments the extent of involvement

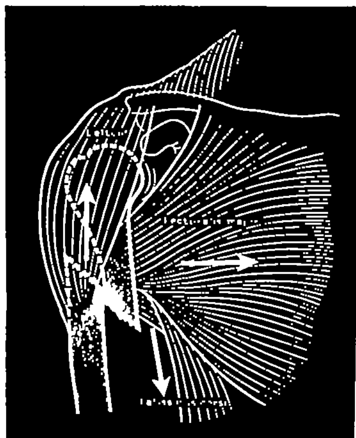


FIG 112 FRACTURE IN UPPER PORTION OF SHAFT OF HUMERUS
The displacing effect of the muscles is indicated by arrows

depending upon the severity of the injury to the arm There may be associated injuries in the shoulder and chest

Prognosis In children these fractures unite within six weeks Spiral fractures unite more readily although with a large amount of callus Moderate shortening in the upper extremity from union with overlapping is not disabling and may be scarcely noticeable In adults transverse fractures in the middle of the shaft unite slowly and non-union sometimes occurs regardless of prolonged immobilization In most instances musculospiral paralysis subsides spontaneously within six months Compound fractures

Treatment If available a Murray-Jones humerus splint with adhesive traction should be applied, or the arm may be bound with lateral board splints and bandaged to the chest in a sling for emergency care. The form of treatment should be chosen according to the individual and the fracture as soon as X ray films have been developed.

Fractures of the shaft in infants and children are seldom displaced. Fasten a gauze pad in the axilla and bind the arm with a coaptation splint made of tongue blades and adhesive plaster for four weeks, holding the wrist to the neck with a loop of bandage.

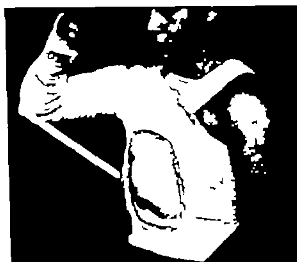


FIG 116A IMMOBILIZATION WITH A PLASTER SPICA

The plaster should extend from the knuckles to the iliac crests. The salute position maintains abduction flexion and external rotation, and thus prevents limitation of movements due to abduction contracture. A window is cut over the abdomen to provide room for distension. A stick is fastened in the plaster for greater strength. This form of immobilization is much more effective and more comfortable than a brace. It is indicated especially for fractures in the shaft of the humerus and for certain fractures in the neck of the humerus when delayed union is expected.

For overriding fractures in adults manipulate with traction upon the flexed elbow using complete anesthesia such as ether or Pentothal sodium. If successful apply a sugar tong splint as described below being careful to prevent angulation. If the fragments still overlap a number of forms of traction may be considered such as adhesive traction skeletal traction through the olecranon process and the Caldwell hanging cast.[1] The hanging cast is the most satisfactory for the majority of cases, and simply consists of an unusually heavy circular plaster of Paris dressing which extends from the knuckles to the axilla with the elbow held at a right angle (See Use of plaster of Paris page 59.) A sling is fastened to the wrist portion of the plaster and extends around the neck. While wearing this the patient should use the hand frequently to prevent stiffness of the thumb



FIG 115 TREATMENT OF OVERRIDING FRACTURES IN SHAFT OF HUMERUS
This simple method with a Thomas splint combined with adhesive traction may be used for from two to four weeks until sufficient callus has formed to prevent displacement of the fragments



FIG 116 FRACTURE OF HUMERUS BEFORE AND AFTER TRACTION
Treated by adhesive traction combined with a Thomas splint This type of fracture in the humerus usually requires prolonged immobilization and sometimes fails to unite

are serious and in war wounds damage to nerves is common The infection and comminution of the fragments and loss of bone substance cause a long period of disability and predispose to non union

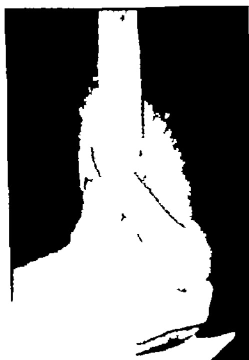


Fig 118 Fracture in Lower Third of Shaft of Humerus

The anterior angulation is typical being caused by muscular contraction This fracture can be treated satisfactorily with the Caldwell hanging cast, combined with a loop of bandage extending from the wrist to the neck



Fig 119 Fracture in Lower Third of Shaft

A posterior plaster splint is satisfactory but the elbow must not be flexed inside an angle of 130 degrees

and fingers, and circumduction exercises of the arm prevent contracture of the capsular ligaments (*For treatment of compound fractures see Chapters II and III*)

In older persons when there is little or no displacement immobilize with a sugar tong splint which is made as follows Immerse two plaster bandages of appropriate width in cool water and lift them out without expressing the water Measure the length of the outer side of the arm and make a reverse



Fig 117 Caldwell Hanging Cast

This is satisfactory for most fractures in the neck and upper shaft of the humerus The weight of the extra heavy plaster of Paris produces traction on the distal fragment Circumduction exercises prevent adhesions and contractures which commonly cause permanent limitation of motion in the shoulder

strip twice this length by overlapping successive lengths of the plaster bandage, rubbing the layers of plaster together Then immediately apply this wet reverse to the bare skin on the outer side of the arm passing it around the flexed elbow and over the inner side of the arm as far as the axilla, and shaping it to the limb by immediately applying a gauze bandage (See Use of plaster of Paris page 59) Support the wrist with a sling the elbow being maintained at a right angle.

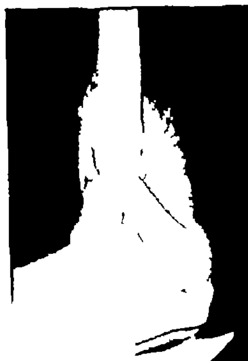


Fig 118 Fracture in Lower Third of Shaft of Humerus

The anterior angulation is typical being caused by muscular contraction This fracture can be treated satisfactorily only with the Caldwell hanging cast combined with a loop of bandage extending from the wrist to the neck



Fig 119 Fracture in Lower Third of Shaft

A posterior plaster splint is satisfactory but the elbow must not be flexed inside an angle of 130 degrees

Follow-up treatment X ray examination should be ordered periodically during the course of treatment to determine the position and extent of union Prolonged immobilization may be necessary, as many of these fractures unite slowly The most secure form of immobilization for delayed union and for compound fractures is a plaster of Paris spica (See Directions for applying a plaster of Paris spica, page 139) Most of the fractures will heal if immobilized long enough, although a bone-graft operation for non-union occasionally is necessary

Precautions Immobilize and reduce these fractures without delay Do not neglect to examine for nerve involvement and always feel for the radial pulse If there are signs of paralysis secure a consultation without delay Avoid over pull, as this predisposes to non union Immobilize



FIG 120 NON UNION FRACTURE IN SHAFT OF HUMERUS
Notice the cupped appearance of the proximal fragment and the rounded condition of the distal fragment forming a 'false joint This condition requires a massive bone-graft operation

until the fragments have united firmly and never give passive movements of the shoulder and elbow as repeated strain on the callus may cause non union Prevent permanent disability from stiffness in the joints of the entire limb by early exercises

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CHAPTER XIV

BONES OF ELBOW

Before considering the various fractures of the elbow joint it will be helpful to review a few of the most important anatomical features of this region The lower end of the humerus articulates during flexion and extension with the upper part of the ulna and it also articulates with the head of the radius for rotation of the forearm The broadened portion of the lower humerus forms the internal and external condyles, the outer, projecting portions of the condyles are known as the epicondyles and the latter are outside the capsule of the joint The lower humerus has two anterior surfaces the one which accommodates the ulna being called the trochlea and the other which articulates with the head of the radius being called the capitellum The trochlear surface of the humerus is not directly in line with the shaft of the humerus but lies anterior to it As the internal condyle is on a lower level than the external condyle there is an obliquity in the articulation which produces the carrying angle as the elbow is held in the extended position

Etiology Most of the fractures in the lower end of the humerus occur in children These injuries are the result of force transmitted up the forearm by falls upon the outstretched hand or they may be caused by falling on the flexed elbow The supracondylar fracture is the commonest occurring in 50 per cent of all elbow fractures and is seen between the ages of eight and twelve years The dicondylar form of fracture is less common The condyles alone are involved in 25 per cent of elbow fractures The intercondylar form and T fractures and Y fractures are seen in adults, these often are severely comminuted and compound

Examination In examining the elbow the three bony landmarks used are the external condyle the internal condyle and the olecranon process When the elbow is held at a right angle these three points form a triangle the base of which is a line connecting the condyles however on account of the extreme swelling which soon develops after traumatism it may be impossible to feel the landmarks or to localize a fracture by palpation The age of the patient and position in which the elbow is held give some idea of the type of injury

X ray examination should be ordered immediately after every elbow injury as prompt diagnosis and treatment are very important In children if there is any doubt as to the nature of injury as determined by the routine X ray film the opposite elbow should be X rayed in the same attitude and projections for comparison Normally in a lateral view the

articular surface is found anterior to the shaft of the humerus In interpreting X-ray films of children it is important to understand the ossifications of the lower end of the humerus The center of ossification for the capitellum appears at the second year and the next to appear is the internal condyle at the fifth year The center for the external condyle is seen at the ninth year These centers fuse at the seventeenth year All injuries of the elbow should be examined for signs of nerve involvement

Complications Limited motion is a frequent sequel to elbow fractures This may be due to adhesions from the accompanying injury to the muscles and ligaments may be due to incomplete reduction with bone-block and to excess callus formation Also the thickened scar in the capsular ligaments with contracture of the capsule is a common cause of limited motion

Myositis ossificans or the ossification of a hematoma in the muscles on

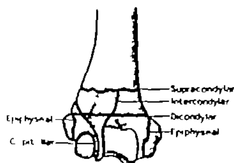


Fig 121 Composite Diagram
Location of fractures which occur in the lower end of the humerus

the anterior surface of the elbow sometimes occurs after severe injuries This may cause permanent limitation of motion.

Volkmann's ischemic paralysis is generally attributed to constriction by tight dressings or to pressure from splints although it may occur when no splints or bandages are used The most plausible explanation is an extensive hemorrhage in the substance of the flexor muscles and under the deep fascia, which produces an acute ischemia The resulting deformity is characterized by early atrophy and contractures of the wrist and fingers with fibrosis and loss of power in the forearm muscles

Cubitus varus or loss of the normal carrying angle causes gunstock deformity or a disturbance of the normal obliquity of the lower end of the humerus The normal carrying angle when the elbow is held extended averages 170 degrees Uncorrected displacement causes a loss of this angle

Cubitus valgus or increase in the carrying angle follows unreduced fractures of the external condyle This deformity and the resultant tension

on the ulnar nerve predisposes to late paralysis, which typically appears in adults many years after the injury

Involvement of the median radial and ulnar nerves may occur with any elbow fracture, being caused by the original traumatism or subsequently by the constriction of callus When the median nerve is completely involved at the elbow there is loss of sensation in the thumb first and second fingers and half of the third finger, there is paralysis of the pronators of the forearm, of the flexors of the wrist and of the opponens pollicis Complete

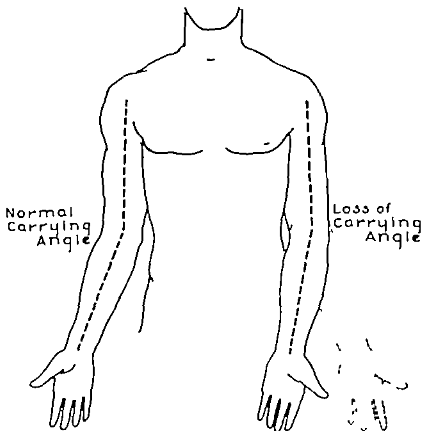


FIG 122 CUBITUS VARUS OR GUNSTOCK DEFORMITY

This loss of the normal carrying angle is a result of uncorrected fractures in the lower end of the humerus after apparently trivial injuries The dotted outline indicates the normal carrying angle which averages 170 degrees

involvement of the radial nerve produces paralysis of the extensors of the wrist thumb and fingers Complete involvement of the ulnar nerve causes loss of sensation over the ulnar half of the third finger and of the entire fourth finger there is motor paralysis of the flexor carpi ulnaris the hypothenar muscles and of the adductor pollicis

Associated conditions may be infection from compound injuries fracture of the head of the radius and fracture of the olecranon process

Prognosis Prompt and accurate reduction is the chief factor in com

plete recovery The damage to the soft structures and the resulting adhesions and contractures depend more upon the nature of the traumatism than upon the size of the fracture Function after multiple fractures without reduction is poor, the results of open reduction are fairly good Fractures in the lower end of the humerus unite within four to six weeks but restoration of function often requires persistent exercising and physiotherapy for several months Many children are frightened and do not cooperate in recovering function by exercising the elbow and resist passive motions in such instances convalescence is prolonged and recovery is even further delayed by forcible movements

Treatment All of these injuries are emergencies and should be treated without delay Immediate reduction is easier than late reduction and replacement of the fragments relieves edema Hospitalization is advisable for all severe elbow fractures General anesthesia is best for most cases Unless these fragments are manipulated early the early formation of callus acts as a hindrance to later reduction Order an X ray examination immediately after manipulation Residual displacement will cause limitation of motions on account of bone-block and in such an instance manipulation must be repeated

As a general rule all fractures of the lower end of the humerus should be immobilized in the attitude of hyperflexion In this position the triceps *acts as a tight band and holds the fragments of the supracondylar fractures* together and the displacing pull of the flexor muscles is relaxed for other fractures However the physician should be careful of this acute flexion position and if pain increases or edema continues the elbow must be immobilized in less flexion Splints are seldom necessary the general utility dressing being the Ashhurst bandage This includes the entire arm and forearm and encircles the neck as a sling (For the treatment of compound fractures see Chapter III) Immobilize infected fractures of the elbow at a right angle with the forearm supinated as this is the most useful position in event of ankylosis

Supracondylar fractures The break is located about one inch above the elbow joint and usually is somewhat oblique The lower fragment is displaced posteriorly with the forearm bones and it also may be rotated and displaced laterally The upper fragment is displaced anteriorly producing a fulness in the front of the elbow As the fracture is located outside the elbow joint there is no distention of the joint capsule but there is generalized edema and enlargement of the entire area from hemorrhage On account of the periosteum being torn the fragments are freely movable This fracture should be differentiated from posterior dislocation of the ulna with dislocation there is rigidity and lack of crepitus Exact diagnosis of the location and displacement of this fracture can be made only by X ray examination

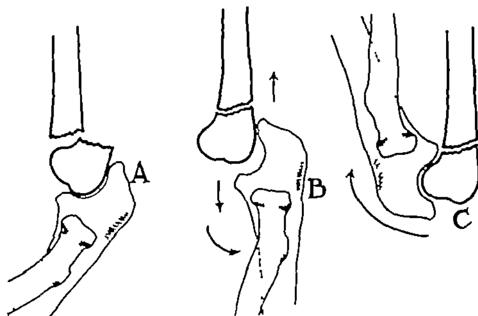


FIG 123 SUPRACONDYLAR FRACTURE OF THE HUMERUS
A typical displacement B reduction by traction and hyperextension C reduction maintained by the acute flexion position



FIG 124 T FRACTURE IN LOWER PORTION OF HUMERUS
This condition is treated best by skeletal traction through the olecranon Open reduction and fixation is an alternative form of treatment for some cases

It is of the utmost importance to examine and treat this fracture at the earliest possible time as the sharp fragments already may have caused serious damage to the vessels and nerves and even greater swelling and

hemorrhage take place if treatment is delayed The muscle spasm and the early formation of callus which occur add to the difficulties of reduction

The anatomy and displacement of the fragments should be visualized with the aid of the X ray films which should be in full view during manipulation of the fracture Complete relaxation under anesthesia is essential, and ether is still the most satisfactory agent under most circumstances With experience one can learn to feel the position of the fragments and



Fig 125 Transcondylar Fracture of the Humerus
Note the typical posterior displacement of the distal fragment also mesial displacement

govern manipulation by his finger tips The typical displacement of the lower fragment must be corrected by strong traction on the extended elbow while forward pressure upon it is made with the fingers At the same time backward pressure is made on the shaft fragment while the forearm is supinated and the elbow is carried into the acutely flexed (Jones) position By carrying the patient s hand toward the front of his shoulder during this manipulation rotation of the distal fragment is prevented and thus gun stock deformity is avoided In most instances after reduction the frag

ments will remain fixed if the elbow is held in this flexed attitude, however, it should be understood that the Jones' position does not actually correct the displacement but merely maintains reduction Accurate reduction is important and if the X ray examination immediately after manipulation does not show satisfactory reposition the elbow should be manipulated again without delay It must be remembered that the lower end of the humerus projects forward from the perpendicular line of the shaft, and unless the distal fragment is completely replaced the patient never will be able to flex the elbow completely Reduction of these frac

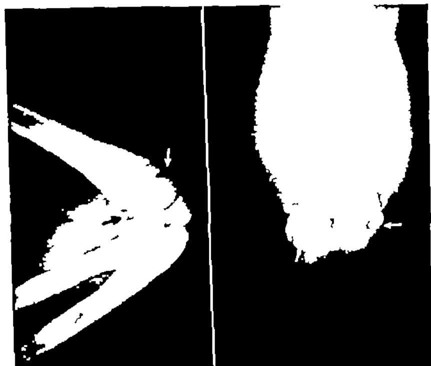


Fig 126 Transcondylar Fracture of the Humerus
The same fracture as shown in the preceding film after reduction by traction and flexion combined with forward pressure on the distal fragment

tures usually reduces the swelling but some of them are accompanied by such extensive hemorrhage and edema that the acutely flexed position causes serious interference with circulation of the forearm With this possibility in mind the radial pulse should be palpated before applying any form of dressing, and if the hand is cyanotic or cold it is advisable to keep the child under continuous observation with the limb simply placed on a pillow in a relaxed position If the circulation has improved by the following day manipulation should be repeated to correct the displacement, and then the elbow flexed to keep the fragments reduced If the hyper flexion position obliterates the pulse less flexion may be sufficient to hold

the fragments and yet not cause circulatory trouble The occasional formation of blebs over the elbow indicates a decided circulatory disturbance, and all fixation should be removed When the fragments are displaced and this bleb formation or excessive swelling prevents manipulation and hyperflexion, the fracture must be managed by traction in bed This form of treatment also is necessary in treating many oblique fractures, for when the fragments are broken on a slant they cannot be held simply by bandaging in the flexed position

Dicondylar Fractures. *These fractures extend transversely through the olecranon fossa and immediately above both condyles of the humerus* As the injury is inside the capsule there is a decided effusion and hemorrhage

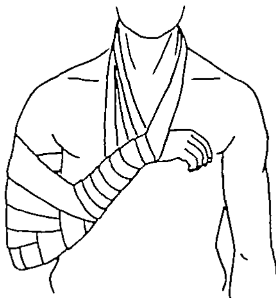


FIG 127 ASHHURST DRESSING FOR FRACTURES OF THE ELBOW
This dressing maintains the acutely flexed position The bandage around the neck is continuous with that around the elbow

in the joint The displacement of the fragments is similar to that of the supracondylar form but as the lower fragment is very short reduction is more difficult Even after reduction there is a pronounced tendency for the fragments to slip Accurate reduction of such fractures which enter the elbow joint is important The same manipulation as for supracondylar fractures is used with particular attention to prevention of gunstock deformity by holding the hand in a line with the front of the shoulder of the same limb as the elbow is flexed It may be impossible to reduce this type of fracture by manipulation on account of the distension of the joint or it may be difficult to maintain reduction on account of this distension, in such instances continuous traction in bed is necessary Skeletal traction through the olecranon process may be used instead of adhesive plaster

In some cases X ray examination immediately after manipulation shows satisfactory reposition but check-up films within a day or two show that the fragments have slipped, in these cases and when there is excessive swelling continuous traction must be applied



FIG 128 ADHESIVE TRACTION ON THE ELBOW

Traction for supracondylar and transcondylar fractures of the humerus is necessary when excessive swelling and displacement prevent reduction by manipulation and immobilization in the flexed position If lateral traction is added the near side of the bed is elevated with shock blocks

Isolated fractures of the condyles For practical purposes separations of the epiphyses and fractures of the condyles may be considered as being identical except that epiphyseal separations occur more often in younger children before the bony structures have become solid The epicondyles are the outer projecting portions of the condyles and are outside the elbow joint capsule Fractures of the condyles are relatively common while

separations of the epicondyles are rare For practical purposes the injuries of epicondyles and condyles will not be differentiated



FIG 129 FRACTURE OF EXTERNAL CONDYLE OF HUMERUS
With such extensive displacement there always is a complete rupture of the external lateral ligament and usually open reduction and fixation of the fragment is necessary



FIG 130 NORMAL ELBOW
X ray examination of the normal elbow for comparison is advisable as the appearance of the epiphyses may be misleading

Fractures of the external condyle These are more frequent than those of the internal condyle and the displacement of the bone varies according to the severity of violence which caused it The line of fracture is oblique and extends into the joint There may be only a separation as in sprain fracture, or the fragment may be widely displaced and drawn outward and

backward with as much rotation as 90 degrees The displacement is due to the contraction of the extensors of the wrist and hand which have their origin on the condyle This injury produces swelling tenderness lateral mobility and crepitus Both elbows should be examined in exactly the same attitudes for comparison and in comparing the films it is important to note even a slight displacement of the epiphysis In every fracture of this nature it is important to recognize such displacement and its final significance Unless the displacement is corrected non-union and consequent deformity from an increased carrying angle will follow In many such instances a late ulnar nerve paralysis develops on account of gradually increased tension on the nerve For loosening or slight displacement of the condyle immobilize the elbow at a right angle thereby relieving the



Fig 131 Fracture of Internal Condyle of Humerus

There is decided rotation and displacement With such fractures there may be involvement of the ulnar nerve In some instances the condyle is displaced into the joint Manipulation is ineffective open reduction and fixation being necessary

muscle pull If the condyle is markedly displaced manipulation is ineffective on account of contraction of the muscles which have their origin on this portion of the bone Under this circumstance operation is necessary the usual procedure being to fasten the condyle with a screw or nail

Fractures of the capitellum sometimes occur in older children the line of fracture extending through the trochlear surface of the humerus If displacement cannot be corrected by manipulation and acute flexion the capitellum must be replaced by operation in order to prevent interference with function of the elbow and forearm

Fractures of the internal condyle The causative force also may produce a fracture of the head or neck of the radius or a dislocation of the ulna With this injury which usually is caused by hyperabduction of the elbow the flexors and pronators attached to the condyle pull it off drawing it

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FIG 129 FRACTURE OF EXTERNAL CONDYLE OF HUMERUS

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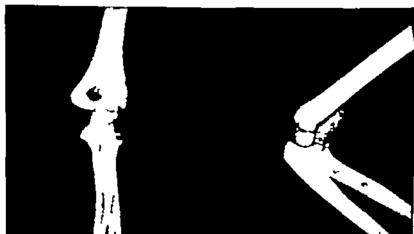


FIG 130 NORMAL ELBOW

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FIG 131 FRACTURE OF INTERNAL CONDYLE OF HUMERUS

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downward and forward In severe cases the internal lateral ligament is badly torn and thus there may be an accompanying dislocation of the elbow Diagnosis by palpation is unsatisfactory and X ray examination is necessary For accuracy comparison films of both elbows in the same attitude should be made There may be a loosening of the epiphysis without X ray evidence of this Usually the X ray appearance is typical, showing the condyle absent from its normal position with characteristic widening of the joint space Occasionally the epiphysis is displaced so far as to be caught in the joint between the olecranon process of the ulna and the trochlear surface of the humerus The ulnar nerve may be injured by the original violence or may be involved by the subsequent formation of callus This fracture may be followed by growth disturbance especially



FIG 132 FRACTURE OF INTERNAL CONDYLE OF HUMERUS
After open reduction and fixation with a stainless steel nail

if the condyle is not completely replaced For loosening or slight displacement flex the elbow to a right angle to relax the muscles In most instances complete replacement can be accomplished only by operation the internal lateral ligament of the elbow should be repaired at the same time

T- and Y-fractures. Comminuted fractures in the lower end of the humerus often are accompanied by fractures of the head of the radius or of the olecranon process of the ulna Such damage occurs typically in adults and is caused by violent direct injury compound fractures in this location are not uncommon The median ulnar and radial nerves may be injured The fragments usually are decidedly displaced and the elbow joint is greatly distended If the fragments are in satisfactory position the elbow should be immobilized at a right angle With every severe fracture involving the articular surfaces of the elbow permanent limitation of motion

must be expected. An attempt should be made to replace the fragments by manipulation. In some instances skeletal traction through the olecranon process is satisfactory. If the fragments cannot be reduced by these methods open reduction is indicated. Such an operation, although technically difficult usually is followed by a fairly good functional result if performed soon after the injury. When the fragments are comminuted and displaced excision should be considered. (For treatment of compound fractures see Chapter III.)

Follow up treatment. Continue immobilization in the same position necessary for reduction until union is complete usually for six weeks. Then encourage active motions including gradual extension. Periodic X ray examination during convalescence is important as the fragments may slip. In most cases the weight of the forearm brings the elbow down during the first week or two after the bandage has been removed but as the complete range of flexion is easily lost the elbow should be replaced in a loop of bandage passing from the wrist to the neck every night for a few weeks. Passive motion is harmful as it may displace the fragments, and it also causes excessive scar tissue formation. (See Restoration of function page 81.) In children heat massage and electrical stimulation are seldom necessary as function usually is restored by play.

When flexion contracture at the elbow persists it may be stretched out by a wedging cast. Limited flexion may be improved by the use of a tape and buckle for gradual take-up. If flexion is prevented by bone-block the projecting portion of bone should be removed.

Myositis ossificans is difficult to treat. Manipulation or forced movements makes this condition worse. Removal of the calcified mass causing stiffness at the elbow never should be attempted until at least six months after the injury.

If Volkmann's ischemic contracture occurs it should be recognized in its early form and treated immediately by incising the fascia of the forearm in order to evacuate the underlying hematoma. Special splints should be fitted for gradual correction and stretching of contractures. In most instances radical operations are eventually necessary.

Gunstock deformity or loss of the normal carrying angle if persisting should be treated early by open reduction of the fracture however this condition seldom is noticed until after the fragments have united and then an osteotomy is necessary. Increase in the carrying angle also should be corrected by a similar operation.

Injury to the median radial or ulnar nerves are treated by splinting and physiotherapy or by operation depending upon the individual case.

Precautions. Fractures in the lower end of the humerus are difficult to treat and in severe cases a consultation is advisable. Unless these are

treated promptly so much edema and organization of the hematoma occurs that complete reduction by any method may be impossible. The acute flexion is satisfactory for most elbow fractures but not for all. Avoid obliteration of the circulation by the acutely flexed position and change the position to a right angle or even less flexion until the radial pulse can be felt. Watch the progress carefully, and examine the condition daily during the first week looking for signs of nerve involvement. The physician should realize that many displaced fractures of the elbow cannot be treated successfully except by operation. Do not give passive motion as this increases muscle spasm and may cause malunion or myositis ossificans.

Fractures of the olecranon process of the ulna. *Etiology.* The olecranon process fits snugly into the olecranon fossa of the humerus while



FIG 133 OLD FRACTURE THROUGH EXTERNAL CONDYLE OF HUMERUS
The stretching produced by the displacement and consequent increase in the normal carrying angle has caused delayed ulnar palsy which appeared many years after the injury

the elbow is completely extended. The main portion of the triceps tendon is attached to the olecranon although its aponeurosis spreads out laterally and extends to the fascia of the forearm. Fractures of the olecranon are somewhat similar to fractures of the patella, as to their anatomy mechanism and varieties. Most of these injuries occur in adults being caused by a combination of direct and indirect violence such as a fall upon the *forearm with the elbow partially flexed. The majority of the fractures* are located at the base of the process and are transverse and complete, the pull of the triceps causing separation and upward displacement. Often when fractures are caused by blows the aponeurosis is not torn and thus there is comminution although no gross separation of the fragments.

Examination. Severe injuries produce ecchymosis and marked swelling at the point of the elbow and often distention of the elbow joint from a

hemarthrosis With complete fractures a depression is palpable between the fragments because the process is displaced upward by the triceps With comminuted fractures there is little displacement and crepitus is present When examining the X ray films of children s elbows the nor mally ununited epiphysis should not be mistaken for a fracture

Prognosis Accurate approximation of the olecranon fragments is fol lowed by bony union although fibrous union may result from interposition of the aponeurosis or uncorrected displacement Even fib ous union is strong enough for good function A majority of olecranon fractures are

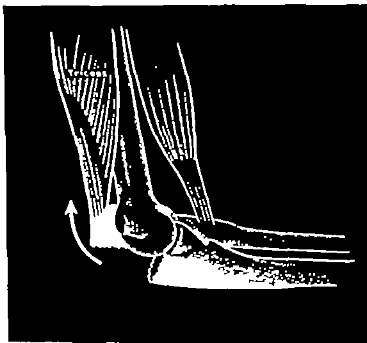


FIG 134 FRACTURE OF THE OLECRANON PROCESS
Illustrating the effect of muscle pull while the elbow is held in flexion

followed by a satisfactory range of motion although arthritic changes in older persons may cause chronic aching and limited flexion

Treatment When the fragments are not separated because the aponeu rosis is intact immobilize the elbow at a right angle with a sling for four weeks and encourage early movements When the olecranon is separated extend the elbow for approximation of the fragments and immobilize in this position with a molded plaster posterior splint for eight weeks (See Use of plaster of Paris page 59) Some surgeons advise operative repair for earlier function although in most instances conservative treatment is considered satisfactory With fractures of the olecranon in persons of advanced age simply use a sling and encourage early movements the resulting function with fibrous union is satisfactory

Fractures of the coronoid process of the ulna The coronoid usually

is broken by a fall on the outstretched hand, which hyperextends the elbow This fracture may accompany posterior dislocation at the elbow, in such injuries it is sheared off by the trochlear surface of the humerus There is deep pain in the elbow with aggravation upon flexion Diagnosis usually is made by X ray examination Treat this fracture by immobilizing the elbow at a right angle *for six weeks* *If the fragment is displaced and interferes* with joint motion or if it fails to unite and causes chronic pain it should be removed

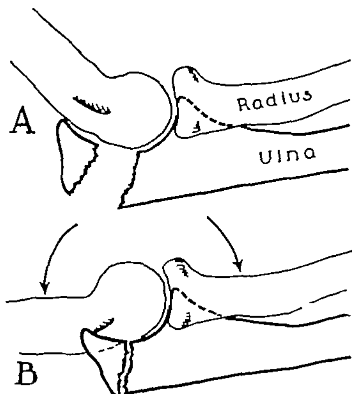


FIG 135 FRACTURE OF THE OLECRANON PROCESS
A separation of the fragments in the flexed position B the fragments have been approximated by relaxing the pull of the triceps in the extended position.

Fractures of the head and neck of the radius. *Etiology* The head of the radius articulates with the ulna in rotation and with the capitellum of the humerus while the elbow is flexed The orbicular ligament forms the joint capsule for the radial head The radius revolves over the ulna for nearly a range of 160 degrees to produce pronation and supination of the forearm In children the entire epiphysis is separated or there may be a fracture in *the neck of the radius* *Fracture in the head of the radius* is a rather frequent injury in adults being caused by direct blows or by indirect violence as in falls upon the outstretched hand The radial head may be split or comminuted and displaced in some instances it is impacted upon the neck of the bone There may be an associated fracture in the upper

portion of the ulna The coronoid, olecranon or capitellum may be broken, or there may be a posterior dislocation of the ulna

Examination The outer border of the elbow is swollen and tender, and in many cases there is a hemarthrosis Rotation of the forearm is limited and causes severe pain, and extreme movements of the elbow joint also are painful When the fracture is complete the head of the radius cannot be felt rotating with the shaft X ray examination should be routine, stereoscopic views being especially useful

Complications Many of these fractures are followed by fibrosis and cicatricial contracture on account of damage to the surrounding ligaments

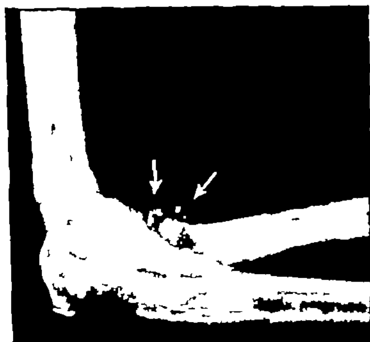


FIG 130 COMMINUTED FRACTURE IN HEAD OF RADIUS
Removal of the entire head and neck of the bone is indicated

There may be associated bony injury and occasionally the radial nerve is involved

Prognosis In children these injuries usually cause no permanent disability unless there is marked displacement and conservative treatment produces good results In adults pain and limitation of forearm rotation and elbow movements are common on account of the formation of scar tissue in the orbicular ligament or irregularity of the radial head Residual deformity causes traumatic arthritis *If displaced or comminuted fractures* are operated upon early and exercises are carried out thoroughly and soon afterward there will be a satisfactory result in most instances although limitation of rotation is common The shortening of the *radial side* of the forearm caused by removing the head and neck eliminates the normal

obliquity in the inferior radio-ulnar joint, which in some cases is followed by chronic aching and weakness in the wrist

Treatment In children treat fractures in the head or neck of the radius without displacement by immobilizing the elbow at a right angle with the forearm supinated for four weeks If there is marked displacement manipulation is useless and the alinement should be corrected by operation but the head should not be removed

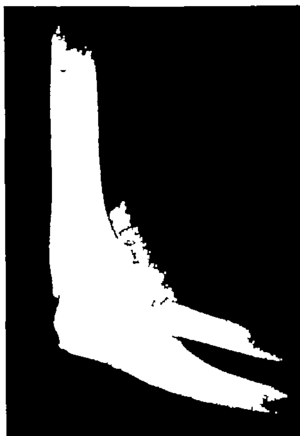


FIG 137 MYOSITIS OSSIFICANS, PRODUCING ANKYLOSIS

Generalized ossification around the elbow joint which occurred after a fracture of the head of the radius This is a result of the extensive damage to the soft parts which accompanied the fracture Note that the radial head has been removed

In adults treat linear fractures which are not displaced with a sling heat and massage and encourage early easy movements (See Physiotherapy and motions, page 81) When the fragments are displaced they cannot be replaced by manipulation on account of the swelling and depth of the fracture, and early operation is necessary to secure the best result No attempt should be made to replace the fragments as excision is the most satisfactory treatment If less than one third of the head is broken the usual practice is to leave the remainder if more than this is involved the entire head and upper portion of the neck should be removed

Follow up treatment Heat and massage are useful in reducing edema and hemarthrosis Exercises for elbow and forearm movements should be followed thoroughly for several months Useful forms of occupational therapy are sawing for elbow function and working with a screw driver and draw knife for rotation of the forearm After operation it is important to order early motion supplemented by heat and massage in order to prevent the contracture of scar tissue (See Physiotherapy and motions page 81)

Precautions Do not fail to diagnose these fractures on account of the absence of deformity crepitus and abnormal mobility Order X ray examination routinely after every severe joint injury Request an early consultation for every case in which there is displacement Begin motions as soon as possible on account of the extensive fibrosis which usually complicates these fractures

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CHAPTER XV

FOREARM BONES

Fractures in the shafts of the forearm bones. *Etiology* The forearm serves as a support to place the hand in various attitudes The anatomical features of the two bones are entirely different The ulna large in its upper position is the important part of the forearm in its articulation forming the elbow joint It tapers from above downward, the lower portion being of relatively minor importance in the construction of the wrist joint In the lower portion of the forearm the radius is the more important The purpose of the upper end of the radius is rotation of the forearm at its lower end it becomes larger to form the wrist joint

Fractures in the shafts of the forearm bones occur in children and adults These injuries in children usually are due to indirect violence as a fall on the outstretched hand A greenstick fracture may involve either one or both bones or there may be a transverse fracture of both bones about one inch above the wrist with overlapping of the fragments

In adults fracture in the shaft of one or both bones at the same level is caused by direct violence whereas in oblique fracture of both bones at a different level the cause usually is severe indirect violence When both bones are broken at the same level the muscle contraction usually causes angulation or overlapping of the fragments A severe injury near the elbow may produce a fracture in the upper third of the ulna associated with dislocation of the upper portion of the radius, this combination is known as a Monteggia fracture (See Dislocations of the radius)

Examination In small children incomplete or greenstick fractures cause only moderate pain and severe injury may be indicated only by the apparent uselessness of the arm (pseudo-paralysis) More severe green stick fractures cause swelling with bowing deformity The contour of the injured forearm should be compared with that of the uninjured forearm When there is severe pain without deformity or crepitus, the pencil rolling test is useful extreme point tenderness under the pencil indicates a fracture which might not be detected otherwise When the radius alone is fractured there usually is displacement but fractures of the ulna alone seldom are displaced.

In adults displacement is common with severe pain swelling deformity crepitus and abnormal mobility If only one bone is broken the other bone may act as a splint and prevent gross displacement of the fragments When *both bones are broken usually there is marked displacement* and the

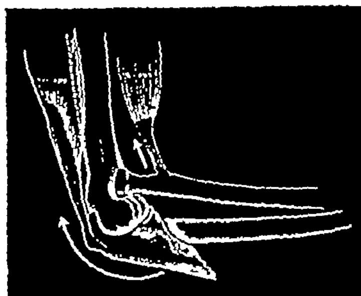


Fig 138 Monteggia Fracture

Fracture of the upper shaft of the ulna combined with dislocation of the radius The arrows show the displacing effect of the muscles Operative reduction and fixation usually are necessary

Fig 139 Green-Stick Type of Fracture Common in Children

Note the incomplete lines of fracture, with typical angulation The bones must be broken completely to correct the deformity

contraction of the forearm muscles causes overlapping by the distal fragments Displacement in the upper third of the forearm is caused by the action of the biceps and supinator brevis, in the mid third by the pronator radii teres and in the lower third by the pronator quadratus Although damage to the nerves and larger vessels is not common in forearm fractures, this possibility should be kept in mind during the examination X ray films should be exposed always in exactly anteroposterior and lateral planes, with the forearm held midway between pronation and supination

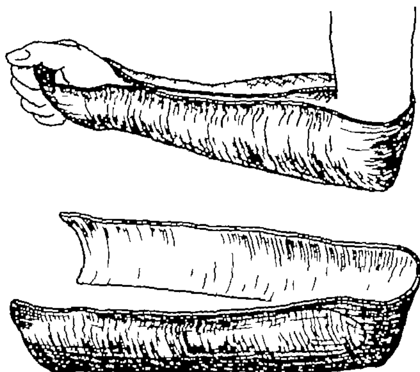


FIG 140 SUGAR TONG PLASTER SPLINT

This is the most satisfactory form of immobilization for fractures in the shaft of the forearm bones and for Colles fractures. A reverse is made by overlapping sections of one or two plaster bandages and is applied immediately to the forearm before it commences to harden

Prognosis It is more difficult to manage forearm fractures than many *other fractures on account of their anatomical features* and the importance of complete function In children the functional results are good regardless of moderate displacement of the fragments As union after greenstick fractures is mostly endosteal there is scanty callus formation and refracture is common In adults poor functional results are common and mal union is frequently seen Cross-union between the forearm bones causes permanent loss of rotatory movements although overlapping of both bones without angulation may be followed by a good result both as to appearance and function Fractures in the middle and lower thirds of

the forearm in adults unite slowly, the average length of immobilization being three months. Delayed union is common on account of the inadequate splinting often used and in such instances late angulation may occur



FIG 140a SUGAR TONG SPLINT

The assistant should support the limb in the perpendicular position during the application of a sugar tong or any other form of splint for fractures in the shaft of the radius and ulna. This position prevents the displacement or angulation of the fragments which often occurs if the forearm is held horizontally while the fracture is being immobilized



FIG 141 FRACTURES OF BOTH FOREARM BONES AT THE SAME LEVEL

This illustrates the typical rotation and crossing of the fragments produced by contraction of the supinators

Non-union is seen most often after compound fractures but occasionally follows simple fractures and may follow open reduction

Treatment Careful splinting immediately after the accident may prevent overlapping of the fragments. Visualize all forearm fractures by

contraction of the forearm muscles causes overlapping by the distal fragments Displacement in the upper third of the forearm is caused by the action of the biceps and supinator brevis, in the mid third by the pronator radii teres and in the lower third by the pronator quadratus Although damage to the nerves and larger vessels is not common in forearm fractures, this possibility should be kept in mind during the examination X ray films should be exposed always in exactly anteroposterior and lateral planes with the forearm held midway between pronation and supination

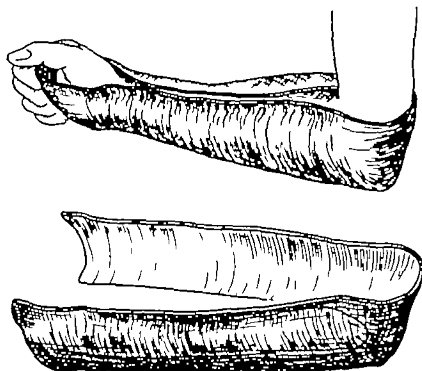


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and supination with a sugar tong splint, as radical treatment is not necessary for a good result

In adults with a fracture of one or both bones in good position, apply a sugar tong plaster splint with the forearm held in a position midway between pronation and supination If the radial fragments are in good position but the ulnar fragments are overlapping do not manipulate because of the liability to cause overriding of the radius and simply immo-

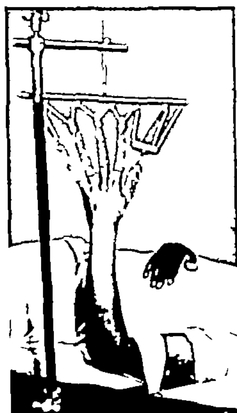


Fig 143

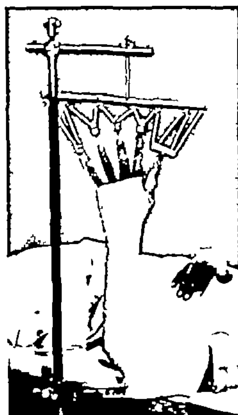


Fig 144

Figs 143 and 144 Use of Caldwell's Finger Traps

Author's traction frame for reduction of fractures in the shafts of the forearm bones and for severe fractures of the wrist Traction is obtained by adjusting the wing nut above with counter traction made by a loop of bandage around the arm Plaster of Paris is applied after the reduction and then the limb is removed from the frame Instead of the arrangement shown small Steinmann pins or Kirschner wires may be used for skeletal traction and transfixion in the plaster

bilize with the sugar tong splint When there is a fracture in the upper third of the radius above the insertion of the pronator radii teres the proximal fragment is supinated by the pull of the biceps and supinator brevis As this fragment cannot be controlled the distal fragment must be brought to it by fully supinating the forearm In fractures of the radius below the pronator radii teres the muscle pull is equalized although in the

having the X ray films before you and do not manipulate without anesthesia Simple fractures with angulation can be corrected satisfactorily with local anesthesia, although the complete relaxation necessary for overriding fractures requires ether by inhalation or Pentothal sodium given intravenously

With greenstick fractures grasp the forearm firmly with both hands and correct the angulation by sudden firm pressure Often it is necessary to produce a complete fracture in order to entirely straighten the limb Immobilize in a sugar tong plaster splint in a position midway between pronation and supination and with the elbow at a right angle

Directions for applying a sugar tong plaster splint Measure the length of the forearm wrist and hand and make a reverse twice this length with one or two plaster of Paris bandages of suitable width The plaster bandage must be immersed in cool water and should be dripping wet not wrung out Overlap successive lengths of the bandage rubbing these together smoothly The assistant should support the limb



FIG 142 SYNOSTOSIS OR CROSS UNION PREVENTING ROTATION

by grasping the fingers holding the forearm in the perpendicular position with the elbow at a right angle thus avoiding angulation or displacement of the fragments Apply the reverse immediately fitting it carefully and without wrinkles over the dorsum of the hand and forearm around the back of the elbow and over the palmar surface of the forearm and hand No padding is required the plaster fitting to the skin Then apply a gauze bandage loosely to hold this sugar tong to the limb Finally cut off the excess length of the splint at the knuckles and palmar crease in order to permit full function of the fingers If the limb swells it is easy to open the sugar tong (See Use of plaster of Paris page 59)

In children with fractures of both bones in the lower portion near the wrist and overlapping manipulation under ether is successful in most cases if performed within the first 48 hours An assistant must hold the upper forearm very firmly Make strong traction upon the wrist and at the same time produce extreme anterior angulation while continuing traction press firmly upon the lower fragments with the thumbs as the angulation is straightened If this form of manipulation fails to correct the overlapping simply immobilize the forearm midway between pronation

Even with early manipulation it is impossible to reduce a very large proportion of these fractures. In such instances it is necessary to decide whether to be satisfied by simply immobilizing with good alinement but with the possibility of cross union or at least limited rotation, or whether to advise more radical treatment which implies some form of operative procedure with a considerable amount of risk and hospitalization. In this decision the age of the patient, his economic and industrial status and the ability of the surgeon must be taken into consideration. The forms



Fig 145 Circular Plaster for Fractures of the Forearm
The plaster extends from the middle of the arm to the knuckles with the thumb and fingers left free for movements. Circular plaster dressings always must be opened or "bivalved" immediately after application to prevent disturbance of circulation and to facilitate removal later

of operative treatment are continuous skeletal traction, transfixion with pins and plaster of Paris, and open reduction and internal fixation. Finally it must be remembered that overlapping fractures of both bones of the forearm in adults are difficult to treat by any method and they are so important that they require the best possible care. (For treatment of compound fractures see Chapters II and III.)

Follow-up treatment Immobilize greenstick fractures and other fractures in children for eight weeks, continuing the sugar tong splint throughout this period. In adults with complete fractures in the shaft of one or

lower forearm the contraction of the pronator quadratus and of the interosseous membrane tend to draw the fragments together. Also the interosseous space is widest when the forearm is in the midway position. For these reasons the best position of immobilizing fractures in the shafts of the forearm bones below the pronator radii teres is midway between pronation and supination.

With fractures of the ulna alone there is little displacement by muscle pull, and the radius acts as a splint. Immobilization with a sugar tong splint is satisfactory. When fracture in the upper third of the ulna occurs



Fig. 144a. Transfixion for Forearm Fractures

Such fractures usually cannot be controlled satisfactorily by splinting alone. Traction and counter traction are made on the Kirschner wires which have been inserted through the lower forearm with the limb suspended in a traction frame (see Figs. 143 and 144). The limb is removed from the frame after the application of plaster of Paris, which includes the wires.

with dislocation of the radius, manipulation under anesthesia may be successful, although most cases require open reduction.

In adults with displaced fractures of both forearm bones reduction by manipulation should be attempted. Complete relaxation under ether or Pentothal anesthesia is necessary. Firm and continuous traction should be made normally or by means of a frame, and after ten minutes of the traction it may be possible to replace the fragments. Then a sugar tong splint should be applied without removing the limb. (See Directions for applying a sugar tong plaster splint, page 174.)

As the swelling of the limb subsides the first splint will be too loose for adequate immobilization, and a second splint should be applied. After the removal of the splinting do not entrust the remainder of the follow up treatment to a physiotherapist or nurse. Active movements and exercises by the patient will not disturb the union, as he will stop on account of pain if the callus is strained. Passive movements, produced by someone else, may cause deformity.

Colles' fracture *Etiology* Colles fracture a common injury in older adults is a break in the lower end of the radius which is caused by a fall on



Fig 147 Fracture in the Lower Forearm in Childhood

The causative force and posterior displacement are similar to those of Colles fracture in adults These fractures may be reduced by the manipulation shown in Fig 30

the outstretched hand Practically all of the patients give a history of falling on a slippery pavement or on a wet or polished floor The force of the impact is transmitted upward from the carpal bones to the articular surface of the radius producing a transverse break about three-quarters of an inch above the wrist joint When a typical Colles' fracture occurs the head of the ulna may be considered as a fixed point around which the distal fragment rotates as it is displaced backward and away from the ulna As the lower portion of the radius is cancellous many of these fractures are impacted and frequently there is comminution A severe fall may also produce a sprain of the internal lateral ligament or a fracture of the styloid process of the ulna

both forearm bones use the sugar tong splint for an average of three months, although more or less time may be required by the individual case Order X ray examinations during the period of immobilization to check on the position of the fragments and the state of union Determine the firmness of union by grasping the limb tightly with both hands and making pressure over the site of fracture with the tips of the thumbs Continue fixation until tenderness and movement at the fracture site have disappeared. Encourage the patient to use the shoulder and hand during the entire time the forearm is immobilized even in performing light work In children reapply the splint at night as an assurance against late angulation

Precautions Study every case carefully being guided by X ray films Never attempt reduction of a forearm fracture without complete relaxation



Fig 146. Non Union Fracture of the Radius
Note the characteristic cupped appearance of the false joint

under anesthesia Nitrous oxide does not produce sufficient relaxation Do not fail to consider the factor of muscle pull as in many cases the position of the fragments immediately after reduction under anesthesia changes within a few hours Do not attempt to reduce a fracture by the pressure or tightness of any form of splinting Never use wooden splints for forearm fractures as these do not immobilize the limb securely and the fragments may sag and unite with deformity The splinting should include the elbow and should not extend beyond the knuckles as full function of the hand during the healing period should be emphasized Do not fail to open the dressing if the fingers become edematous Continue the splinting until the fracture is firmly united or even longer to be certain as removal of the immobilization too soon is a common cause of delayed union and deformity

impacted the dorsal view of the wrist shows a lateral deformity of adduction on account of the shortening of the radius The normal oblique line between the two styloid processes is changed to a transverse line, the radial styloid being on a higher level than normal on account of the displacement Pain is increased by attempts to move the hand There is extreme tenderness over the distal end of the radius and also over the ulnar side of the wrist *When the fragments are not displaced* there is less swelling and pain and the diagnosis may depend upon localized linear tenderness to pressure which can be detected best by the pencil rolling test Crepitus and abnormal mobility cannot be elicited if the fragments



Fig 160 Grip for the Reduction of a Colles Fracture
The distal fragment is rotated and pressed downward and outward with the thumbs as counter pressure is made against the proximal fragment with the fingers

are impacted Colles fracture should be differentiated from sprain or contusion of the wrist separation of the lower radial epiphysis and fracture or dislocation of the carpal bones X ray examination should be ordered routinely after every severe injury of the wrist Do not overlook a fractured scaphoid bone or a dislocation of the semilunar bone when the X ray film does not show a Colles fracture

Complications Chronic aching and limitation of motion in the wrist and hand are frequent in older persons on account of arthritic changes Prolonged edema causes fibrosis with resulting joint contractures Rupture of the radioulnar ligament causes chronic subluxation of the head of the ulna with aching and weakness of the wrist Malunion is common

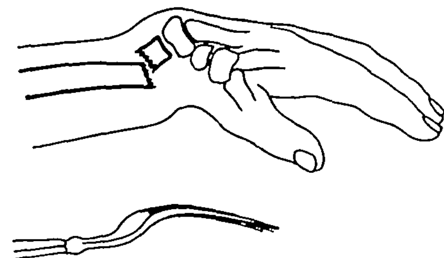


FIG 148. CHARACTERISTIC DEFORMITY OF COLLES FRACTURE
Note the resemblance of the profile view to the lateral outline of an inverted dinner fork

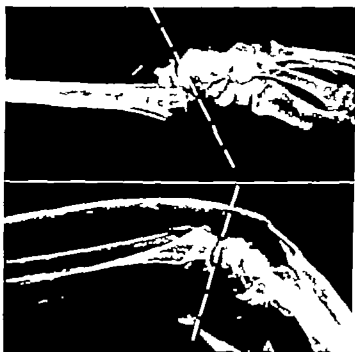


FIG 149 COLLES FRACTURE
The upper film shows backward tilting of the distal fragment Unless this tilting is corrected there will be permanent restriction of flexion at the wrist joint, as well as deformity The lower film shows complete reduction with the articular surface tilted downward and immobilization in flexion

Examination. The hump in the lateral outline of the wrist resembles a fork turned upside down and is commonly described as the inverted dinner fork or bayonet deformity If the fragments are displaced or

impacted the dorsal view of the wrist shows a lateral deformity of adduction on account of the shortening of the radius The normal oblique line between the two styloid processes is changed to a transverse line, the radial styloid being on a higher level than normal on account of the displacement Pain is increased by attempts to move the hand There is extreme tenderness over the distal end of the radius and also over the ulnar side of the wrist When the fragments are not displaced there is less swelling and pain and the diagnosis may depend upon localized linear tenderness to pressure which can be detected best by the pencil rolling test Crepitus and abnormal mobility cannot be elicited if the fragments



FIG 150 GRIP FOR THE REDUCTION OF A COLLES FRACTURE
The distal fragment is rotated and pressed downward and outward with the thumbs as counter pressure is made against the proximal fragment with the fingers

are impacted Colles fracture should be differentiated from sprain or contusion of the wrist separation of the lower radial epiphysis and fracture or dislocation of the carpal bones X ray examination should be ordered routinely after every severe injury of the wrist Do not overlook a fractured scaphoid bone or a dislocation of the semilunar bone when the X ray film does not show a Colles fracture

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and causes an unsightly appearance and in a majority of instances causes permanent limitation of function Displacement also produces unevenness of the grooves for the tendons on the dorsum of the radius with consequent functional difficulty Occasionally the median nerve is affected by pressure of the proximal fragment

Prognosis Complete recovery after Colles fracture depends mainly upon accurate reduction Normal function and freedom from pain in cases with residual deformity is exceptional Failure to correct posterior tilting of the distal fragment causes limitation of flexion When there is an accompanying fracture of the ulnar styloid the wrist obviously has been



FIG 151 COLLES FRACTURE

The first film shows impaction with the normal oblique line between the styloid processes reversed Unless the normal position of the wrist is corrected there will be lateral deformity and aching in the wrist. The second film shows the normal oblique line between the styloids restored with the fragments in proper alinement.

more severely injured and the outlook for early recovery without permanent pain is not as favorable as with a simpler injury Persons past middle age have a decided tendency to stiffness of the wrist and hand and of the shoulder on account of traumatic arthritis due to the fall and the subsequent immobilization Recovery after comminuted fractures of the lower end of the radius extending into the wrist joint is slow and permanent limitation of motion on account of adhesions and capsular contracture is common The average Colles fracture unites completely in eight weeks although there usually is weakness in the limb for several weeks longer

Treatment. Reduce displaced fractures without delay using local or

general anesthesia The principal features of reduction are disimpaction or loosening the fragments if impacted, traction, rotation of the distal fragment into the pronated position as pressure is made toward the ulnar side of the wrist, and finally flexion of the wrist Hold the forearm pronated across your knee and with a short grip on the lower fragment completely disengage it by traction combined with pressure into hyperextension Then press and rotate the distal fragment downward and outward toward the ulna with the thumbs, and at the same time carry the wrist into flexion

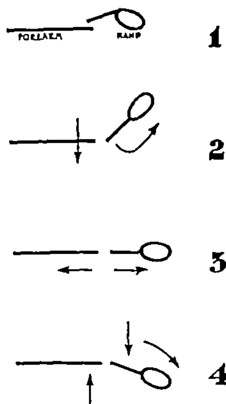


FIG 152. DIAGRAM REPRESENTING REDUCTION OF COLLES FRACTURE

1 typical displacement 2 fragments mobilized or disimpacted by hyperextension 3, traction and counter traction. 4 flexion and rotation of the distal fragment into the down and out position

to correct the posterior displacement of the distal fragment With ordinary fractures there is little tendency for the displacement to recur after reduction has been accomplished Palpate the forearm carefully comparing its outline and movements with the other forearm and being certain that all displacement has been corrected Lay a straight object as a wooden splint, on the dorsum of the forearm and wrist as a test for reduction The normal relationship of the styloid processes should now be found restored Check the reduction by immediate X ray examination and if there is any remaining displacement repeat the manipulation

Immobilize Colles' fractures in the position of pronation moderate palmar flexion and ulnar deviation with a sugar tong splint (See directions for applying a sugar tong plaster splint page 174) As complete movement of the fingers should be preserved no form of splint should extend beyond the palmar crease If the fragments have not been dis

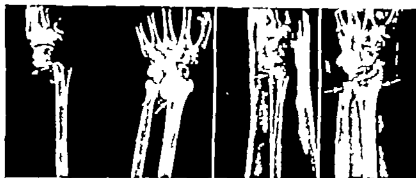


Fig 153 Severe Fractures Above the Wrist
Reduced by traction in author's frame using Caldwell's finger traps (See Figs 143 and 144)



Fig 154 The Proper Use of a Sling
The fingers point to the shoulder Note the extra fold in the sling, which elevates the forearm and thus relieves edema of the hand (after Page and Bristow)

placed or if they are impacted with good position this position should not be used the wrist being immobilized in slight hyperextension on a cock up splint

Follow-up treatment Keep the patient under daily observation for the first week The splint should fit snugly but the bandage should not be so tight as to constrict the circulation Prevent swelling of the hand by

placing the hand at a higher level than the elbow, shortening the sling under the wrist with safety pins Insist upon frequent and complete function of the hand during the entire period of immobilization In persons of middle age and older do not overlook the progressive stiffness of the shoulder which may occur after an injury and by holding the arm in a sling and give abduction and rotation exercises to prevent this Continue the splinting for four weeks when the fracture is transverse but immobilize for six weeks when there is comminution Then prescribe exercises as squeezing a sponge, turning a door knob, washing dishes, wringing a towel



FIG 155 EXERCISE FOR LIMITED MOTIONS OF WRIST FOREARM AND HAND
Wringing a towel is a practical and effective exercise during convalescence from fractures of the upper limb

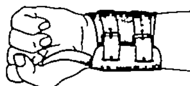


FIG 156 TWO-STRAP WRISTLET
This is useful during convalescence from fractures about the wrist The loop around the thumb prevents the wristlet from slipping upward

and carpentry A two-strap leather wrist band may be worn for a few weeks to support the weak ligaments of the wrist during heavy work

Precautions Do not depend upon the presence of gross deformity for diagnosis as palpation is not dependable on account of the extensive swelling which occurs after such injuries Manipulate without delay and never wait for swelling to subside Never make a diagnosis of sprain unless the X ray examination is negative to fracture Do not hesitate to break up the impaction of a Colles fracture if the position of the fragments is unsatisfactory, as these fractures always unite within a short time Be certain to completely correct the posterior tilting of the distal fragment as failure to do so results in permanent restriction of flexion at the wrist Whatever form of splinting is used should permit free movements of the

thumb and fingers Insist upon full movements of the shoulder, elbow, thumb and fingers throughout the course of treatment As chronic arthritis is frequent after middle life never immobilize Colles fractures in older persons in the attitude of extreme palmar flexion because of the deformity and stiffness in the hand which frequently follows splinting in such a position ✓Do not "turn over the case to a physiotherapist for follow up care after removal of the splint or sugar tong as injudicious manipulation may disturb the union and produce deformity If any other physiotherapy beside that which the patient follows out at home is necessary it should be given under the personal supervision of the doctor

Reversed Colles' (Smith's) fracture. This term is used to designate an unusual condition in which the distal fragment is displaced anteriorly the relative position of the fragments being directly opposite that of the



FIG 157 REVERSED COLLES (SMITH'S) FRACTURE
The distal fragment is displaced anteriorly in the opposite direction to that of Colles fracture

ordinary Colles fracture Reduce this fracture by traction and pressure upon the fragments as the wrist is dorsiflexed After manipulation immobilize the wrist in moderate dorsiflexion with a plaster splint or circular plaster dressing (See Directions for applying a sugar tong plaster splint page 174) The same follow up treatment is indicated as for Colles fracture

Comminuted fractures of the distal end of the radius. These injuries are caused by severe violence and the fragments usually are displaced in several directions In addition the ulnar styloid usually is broken There also may be a fracture or dislocation in the carpus It is not always possible to reduce these fractures completely although the wrist joint is involved and accurate reposition is important for good functional results Extensive injury to the soft tissues produces many adhesions

These fractures should be treated by traction and pressure to mold the fragments with complete relaxation under anesthesia, and for this traction

Caldwell's finger traps are useful. Skeletal traction with a Kirschner wire or small Steinmann pin may be satisfactory, and in some instances it is advisable to incorporate the Kirschner wire in plaster of Paris for transfixion; it may be necessary to introduce a second Kirschner wire through the olecranon process for this purpose. Occasionally it is advisable to operate for replacement or removal of fragments. Such fractures should be immobilized with a plaster sugar tong splint in a straight position, not

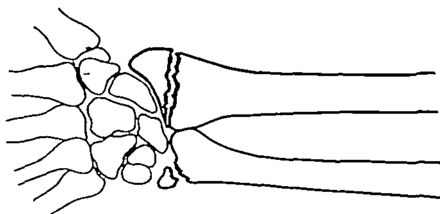


Fig. 158. Chauffeur's Fracture

The wrist was struck by a crank handle due to motor "back fire." The line of fracture extends through the base of the radius. There also is a fracture of the styloid process of the ulna. The fragments seldom are displaced.



Fig. 159. Anterior Plaster Splint

This is satisfactory for minor fractures of the forearm but does not immobilize sufficiently for displaced fractures.

in palmar flexion, on account of the limitation of motion which is expected; the elbow should be included to prevent rotation of the forearm. The thumb and fingers should be left free for activity. After eight weeks a long course of physiotherapy including heat, massage and exercises is necessary on account of the extensive adhesions and contractures which form. In most cases a good range of painless motion finally can be secured by repeated manipulations under anesthesia, combined with other physiotherapy.

Barton's fracture. This fracture at the lower end of the radius extends obliquely and posteriorly into the wrist joint with slight posterior displacement of the distal fragment Reduce the displacement by pressure upon the distal fragment with the thumbs as the wrist is carried into acute flexion and ulnar deviation Use the same immobilization and follow-up treatment as for Colles' fracture

Separation of the lower radial epiphysis. *Etiology* The lower epiphysis of the radius is occasionally separated and displaced by a severe fall



FIG 160 EPIPHYSEAL FRACTURE OF THE RADIUS

The separation and posterior displacement of the epiphysis of the radius in an adolescent is analogous to Colles fracture in an adult There is no lateral displacement.

upon the outstretched hand This condition in adolescents is analogous to Colles fracture in adults

Examination The posterior displacement produces a deformity which resembles that of Colles fracture Moderate force merely loosens the epiphysis causing only tenderness and swelling the site of injury may be determined by rolling a pencil over the lower end of the forearm Severe violence produces complete posterior displacement of the epiphysis with resulting abnormal mobility and a soft rubbing crepitation X ray examination should be routine after every severe injury of the wrist

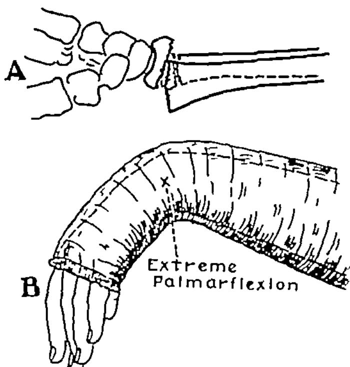


Fig 161 Separation of the Radial Epiphysis

A, typical posterior displacement B reduction by traction and extreme palmar flexion A circular plaster of Paris dressing should be applied to maintain the acutely flexed position

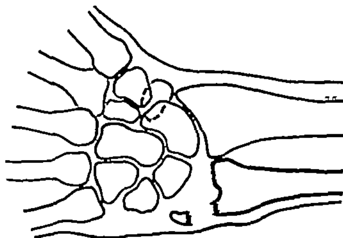


Fig 162 Sprain Fracture at the Wrist

There is an avulsion of the styloid process of the ulna The separation of the styloid is due to a severe sprain or tearing of the ligaments

Prognosis Severe injury of the epiphysis may cause disturbance in growth of the radius Most cases recover in six weeks Immobilization in the extremely flexed position does not cause permanent stiffness

Treatment Unless manipulated without delay the early formation of callus will prevent reduction General anesthesia is preferable to local anesthesia. Hold the forearm pronated and make traction upon the wrist pressing firmly on the epiphysis with the thumbs as the wrist is hyperflexed Immobilize the wrist in hyperflexion with a sugar tong plaster splint (See Directions for applying a sugar tong plaster splint page 174)

Follow-up treatment Continue the immobilization in plaster for six weeks then prescribe exercises as squeezing a wet sponge and wringing a towel

Precautions Correct the displacement of the piphysis by extreme flexion Always use plaster of Paris for this injury as wooden splints cannot fit Repeated attempts at reduction traumatize the epiphysis and may arrest the growth of the radius

Fractures of the styloid processes. *Etiology* These minor fractures may accompany sprains of the wrist (sprain fractures) Fracture of the styloid process of the ulna sometimes occurs with Colles fracture

Examination Isolated fractures cause moderate pain and disability at the wrist There is marked swelling and local tenderness, without deformity The diagnosis is usually made by X ray examination

Treatment Immobilize the wrist in slight dorsiflexion with a sugar tong splint (See Directions for applying a sugar tong plaster splint page 174) Remove the splint after four weeks and order support by a two-strap leather wristband for several weeks longer If the broken styloid process of the ulna fails to unite there may be chronic pain which is relieved only by excision of the fragment

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CHAPTER XVI

BONES OF WRIST AND HAND

Fractures of the carpal bones. *Etiology* The bones of the wrist joint are seldom fractured as they are small and compact and articulate together freely As the carpal bones have a scanty blood supply and a great extent of their surface is cartilaginous union is necessarily slower than in most other bones Fracture of the scaphoid (navicular bone) is the most common being caused by a fall on the outstretched hand This fracture not infrequently is accompanied by dislocation of the semilunar bone Fractures of the trapezium are frequently impacted, and are caused by force transmitted through the first metacarpal bone from severe punching blows on the thumb Multiple fractures of the carpal bones are caused by severe crushing injuries

Examination In every painful disability of the wrist even without deformity the possibility of a fracture always should be considered Many of the cases are misdiagnosed as sprains With fractures of the scaphoid bone the normal depression of the anatomical snuff box is obliterated by swelling and there is tenderness on deep pressure at this point and extreme movements of the wrist produce severe pain With fractures of the trapezium motion of the thumb is limited and painful It is important to order X ray examination after all severe injuries of the wrist as many fractures are recognized only by this routine In questionable cases a thorough examination of both wrists should be obtained, as otherwise a congenital division of a bone may be diagnosed as a fracture

Prognosis Fractures of the carpal bones unite slowly and require prolonged immobilization as their scanty blood supply is interrupted Fractures through the tuberosity of the scaphoid always unite and most fractures through its neck unite although a considerable proportion of linear fractures extending across the body of the bone fail to unite Absorption or aseptic necrosis with the development of traumatic arthritis is frequently seen after fractures of the scaphoid especially those which have been unrecognized or have not had prolonged immobilization Likewise comminuted fractures cause permanent aching and weakness in the grasping power of the hand on account of arthritic changes Uncorrected impaction deformity of the trapezium is followed by permanent pain and restriction of abduction in the thumb

Treatment For fractures without displacement immobilize the wrist in radial deviation and moderately extended in a circular plaster of Paris

dressing extending from the elbow to the palmar crease The thumb should be included and held abducted in the plaster (See Use of plaster

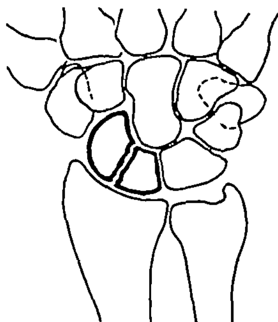


Fig 163 Fracture of the Scaphoid (Navicular) Bone

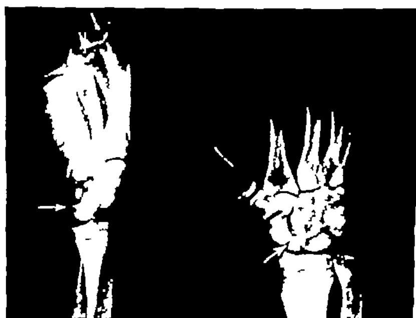


Fig 164 Fracture of Scaphoid with Dislocation of Semilunar Bone Dislocation of the semilunar bone is an occasional complication

of Paris page 59) When the fragments are displaced, give anesthesia and reduce by molding with the thumbs and fingers while an assistant carries the wrist back and forth from hyperextension to flexion Im



FIG 165 FRACTURE OF THE SCAPHOID BONE IMMOBILIZED IN PLASTER OF PARIS
This cast holds the wrist in dorsiflexion and radial deviation and includes the thumb The plaster extends from the knuckles to the upper portion of the forearm and should be opened or bivalved immediately after hardening for safety



FIG 166 KIENBÖCK'S DISEASE
The typical fragmentation of the semilunar bone from traumatic osteitis must not be mistaken for fracture

mobilize the wrist immediately in the circular plaster of Paris cast If there is an associated Colles fracture with displacement immobilize in the position for that fracture For fractures of the trapezium or other bones

use a circular plaster of Paris dressing maintaining the wrist in slight hyperextension permitting full motions of the fingers

Follow-up treatment. Change the plaster monthly and on these occasions order check up X ray examinations Continue the immobilization of scaphoid fractures with an unpadded circular cast for at least four months, or until X ray examination shows union After the first two months a leather gauntlet reenforced with metal strips may be used instead of the plaster For delayed union an even longer period of immobilization in plaster may be effective although some cases proceed to non union For non union, which causes disability due to pain and weakness the most satisfactory treatment is a bone graft operation Excision of the fragments for non-union leaves a decidedly weakened wrist, and is not advisable except when the fragments are decidedly absorbed For the pain and weakness *after multiple fractures of the carpal bones a graft or arthrodesis* operation may be necessary

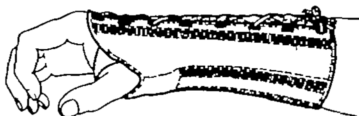


FIG 107 LEATHER GAUNTLET STIFFENED WITH A STRIP OF METAL
This is useful for immobilizing the wrist after fairly firm union has been obtained by immobilization with plaster of Paris

Precautions Order X ray examination after all severe injuries of the wrist since many carpal fractures are misdiagnosed as sprains on account *of the absence of deformity* *If pain continues after an injury* to the wrist with negative X ray findings order another X ray examination as in many instances a fracture line will be evident later after absorption has occurred Always use circular plaster in order to maintain close apposition of the fragments Absorption of the scaphoid from insufficient immobilization is common therefore prolonged fixation is important and must be continued until X ray examination demonstrates bony union or non-union

Fractures of the metacarpal bones. *Etiology* The bones of the hand are superficial and fractures occur frequently especially in industry The first second and fifth metacarpals are more commonly involved than the others on account of their exposed position The weakest portion of the metacarpal bones is in the neck near the knuckle Most of the fractures near the knuckles are caused by punch blows which produce firm impaction Bennett s fracture actually is a fracture-dislocation at the base of the first metacarpal bone caused by a blow on the end of the thumb which

drives the metacarpal against the trapezium Fractures in the shaft of the metacarpals may be oblique, transverse or comminuted Multiple fractures of the metacarpal bones are the result of direct violence as severe crushing injuries, and often are compound



FIG 168 BENNETT'S FRACTURE FRACTURE DISLOCATION AT BASE OF THE THUMB
The second film shows reduction by skeletal traction with Kirschner wire in the distal phalanx with a banjo splint

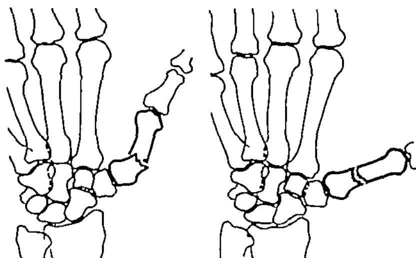


FIG 169 FRACTURE OF METACARPAL BONE OF THUMB
Fractures in the shaft usually have an adduction or flexion deformity and must be reduced by abduction or extension The most satisfactory form of immobilization is a plaster spica

Examination There is edema and localized tenderness with increase of pain by movements of the finger Pain from tapping upon the knuckle or end of the finger is a dependable sign of fracture Displacement and deformity are common, usually consisting of posterior angulation with the

metacarpal head inclined toward the palm because of the pull of the interosseous muscle With impacted fractures near the knuckles these signs may be absent diagnosis being made upon the history of a punching blow with soreness and deformity This deformity may be apparent only as the hand is clenched when the usual prominence of the affected knuckle is absent The X ray *appearance of Bennett's fracture shows the base of* the metacarpal bone displaced dorsally over the trapezium, a small fragment remaining attached to the intact portion of the ligaments In all *doubtful cases the pencil rolling test may detect the point tenderness* characteristic of fractures and X ray examination always should be ordered

Prognosis The metacarpal bones unite within six weeks, and in most instances there is no permanent trouble providing the fracture has been reduced Fractures extending into the metacarpophalangeal joint result

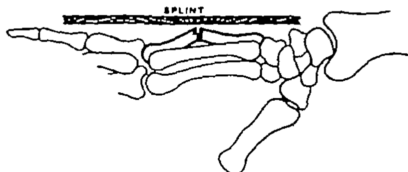


FIG 170 INEFFECTIVE SPLINTING
The tongue blade does not control the fracture as it is too short and does not fit the contour of the hand

in a permanent enlargement of the knuckle often with limitation of flexion The violent force which is required for multiple fractures of the hand also produces severe injury to the tendons and joints, and often is followed by impaired function Uncorrected deformity of a punch fracture near the knuckle causes pain and limited flexion Bennett's fracture causes chronic aching and permanent *limitation of motion unless* completely reduced and held reduced until the bone and ligaments have healed

Treatment Immobilize fractures in the shaft of the metacarpal bone of the thumb in the abducted position with a plaster of Paris spica. The base of the thumb should be well padded. (See Use of plaster of Paris, page 59) Manipulate fractures with angulation under local or general anesthesia and apply a plaster spica to maintain abduction

Treat Bennett s fracture by traction and abduction on the thumb combined with local pressure Local or general anesthesia may be used Lay a piece of felt over the base of the thumb for padding and then apply

a plaster spica with the thumb held in wide abduction, molding the plaster snugly over the fracture If X ray examination after application of the plaster shows residual displacement, insert a Kirschner wire or needle

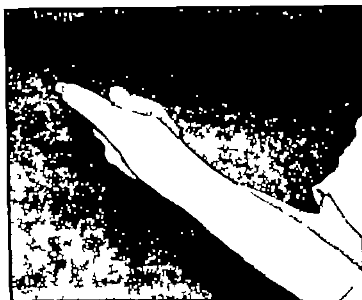


FIG 171 SUGAR TONG SPLINT FOR METACARPAL FRACTURES
The plaster bandage should be immersed in cool water to prevent rapid setting The plaster splint is applied directly to the skin. The upper two-thirds of the splint may be cut off after two weeks



FIG 172 BANJO SPLINT FOR FRACTURES OF METACARPALS AND PHALANGES
A loop of heavy wire has been incorporated in the plaster of Paris and a hold on the finger is obtained with cellulose acetate glue Traction is made with a rubber band the pull being regulated by bending the wire When traction on more than one finger is required the wire loop must extend beyond the entire hand Ordinarily skeletal traction is more satisfactory than the skin traction

through the distal phalanx and make continuous traction in abduction with a loop of wire incorporated in the plaster (See Traction page 67)

Fractures in the neck of the metacarpal bones to the fingers may be impacted without angulation and if so no immobilization is required When there is angulation the metacarpal head is displaced toward the

palm Break up the impaction under general anesthesia, grasping the knuckle firmly with the hands The impaction from a blow often is so firm that it may be necessary to pad the hand well with felt and use a Thomas wrench or clamp in order to disimpact it Then apply an unpadded anterior and posterior plaster splint extending from the middle of the forearm to at least the proximal interphalangeal joint of the finger Mold the plaster as it hardens to hold the metacarpal head in alinement with the shaft



FIG 173 FRACTURES OF ALL THE METACARPAL BONES There was normal function four months after open reduction

Linear fractures in the shaft of the metacarpal bones without displacement may be treated with a posterior splint of wood or plaster In order to immobilize adequately this should extend from above the wrist to the proximal interphalangeal joint of the finger Complete fractures have a characteristic palmar angulation on account of the pull of the interosseous muscle In order to overcome this pull apply an unpadded anterior and posterior splint, which should extend from the lower forearm to the proximal interphalangeal joint of the finger as it hardens the plaster should be molded to hold the fragments in proper alinement Immobilize comminuted oblique fractures in the same manner For treatment of compound fractures see Chapter III

Oblique and comminuted fractures may require continuous traction in a banjo splint For this purpose apply a cellulose acetate dressing to the finger, or insert a Kirschner wire through the phalanx Apply a well padded circular plaster of Paris dressing to the forearm and wrist and incorporate a piece of telegraph wire or coat hanger wire on each side of it to form a loop beyond the end of the fingers Then fasten a rubber



FIG 174 FRACTURE OF A METACARPAL BONE
Unless the palmar displacement of the metacarpal head is corrected there will be permanent deformity with weakness in the hand and pain upon grasping tools

band to the finger and the wire loop for continuous traction the pull is easily regulated by bending the wire loop

Follow-up treatment There is no universal stock splint for metacarpal fractures The most satisfactory form of immobilization is an unpadded plaster of Paris splint which can be used for any position Begin the application of heat and light massage on the entire hand early, being careful to prevent any movement at the fracture by keeping the hand on the splint After immobilization for an average of four weeks encourage

exercises as squeezing a sponge wringing a towel and light carpentry Fibrosis resulting from prolonged edema and infection must be treated by thorough and prolonged physiotherapy (See Physiotherapy and motions page 81)

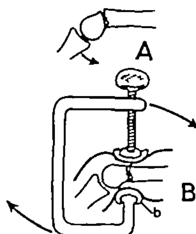


FIG 175 CORRECTION OF A PUNCH FRACTURE

This fracture usually is tightly impacted from the severe blow which caused it and requires a firm hold and sudden twist with a weaver s clamp (Murray s method) The soft tissues must be protected with felt padding.

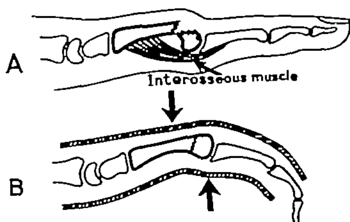


FIG 176 FRACTURE OF METACARPAL BONE

A the typical displacement is caused by pull of the interosseous muscle B the effect of muscle pull is controlled best by the application of plaster of Paris. The plaster is molded as it hardens the points where pressure should be made being indicated by the arrows

Precautions Immobilize these cases for several weeks until there is no further tenderness or movement at the site of fracture, as malunion may result if splinting is removed before union occurs Check the position of the fragments by X ray examinations during the follow-up period Active movements by the patient are helpful for residual weakness and

limitation of motion in the fingers, but passive movements may delay union and produce angulation

Fractures of the phalanges. *Etiology* Fractures of the distal phalanx are common and usually are caused by blows from tools or by crushing injuries, and thus many of these are compound A blow upon the end of the finger may produce a sprain fracture ("baseball finger" or "drop finger) or a fracture-dislocation

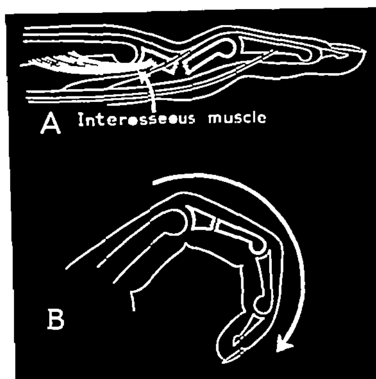


FIG 177 FRACTURE IN SHAFT OF PROXIMAL PHALANX
A typical anterior angulation caused by interosseous muscle B reduction by full flexion

Fractures of the middle phalanx usually are produced by direct injuries Most of them are transverse and angulated

Fractures of the proximal phalanx usually are due to direct injury, the traumatism causing the fracture also injures overlying tendons and adjacent joints

Examination With crushing injuries of the distal phalanx the tip of the finger is extremely swollen and painful and often there is a hematoma under the nail Many of these injuries are compound with extensive laceration of the soft structures Crepitus point tenderness and abnormal mobility are characteristic signs of fractures in the shaft of a phalanx Sprain fractures at the distal interphalangeal joint with avulsion of the

extensor tendon produce a moderate flexion deformity and voluntary extension of the finger is impossible Fracture-dislocations at the inter phalangeal joints have the typical appearance of dislocations X ray examination should be ordered after all severe injuries of the fingers

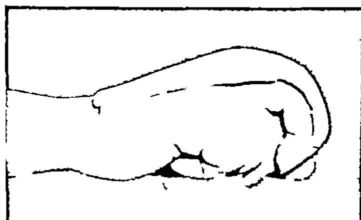


FIG 178 PLASTER SPLINT FOR FLEXED POSITION OF FINGER
A small plaster reverse is applied while dripping wet being cut with scissors to fit and molded snugly to the finger before it commences to set

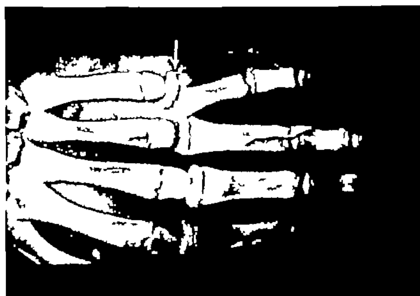


FIG 179 EPIPHYSEAL FRACTURE OF A PHALANX
Treated by manipulation and immobilization in flexion

Prognosis Regardless of competent and prolonged treatment many finger fractures are followed by chronic pain and local disability Persistent edema and infection cause fibrosis which results in limitation of motion Stiffness and pains in neighboring joints are common on account

of the accompanying damage to the skin, tendons and ligaments Fractures extending into joints with damage to the capsular ligaments are followed by thickening and often there is permanent limitation of motion Union with angulation causes permanent disability Mistreated "base-



FIG 180 COMMINUTED FRACTURES OF THE FINGERS

These fractures extending into the joints usually are followed by limitation of movement on account of the accompanying damage to the capsular ligaments and tendons



FIG 181 FRACTURE EXTENDING INTO JOINT

The accompanying damage to the soft tissues produces enlargement of the joint with tenderness and limitation of motion

ball fingers" have a permanent flexion deformity Many compound fractures are followed by infection with resulting osteomyelitis delayed union and ankylosis In most cases osseous union is not evident in the X ray films for several weeks although callus generally becomes fairly firm in two weeks

Treatment The importance of careful treatment of these fractures cannot be over-emphasized, as perfect function of the fingers is essential to all persons The common disregard for attention to details in treatment of these cases is due to their being considered minor injuries, although

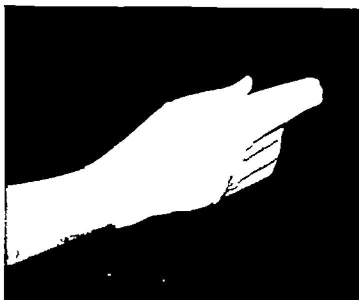


FIG 182 PLASTER SPICA OF FINGER
This is a satisfactory method of immobilizing fractures of a metacarpal bone or phalanx, as any position can be maintained



FIG 183 COMPOUND COMMINUTED FRACTURE OF THE FINGER
This was caused by a crushing blow Infection and fibrosis resulted in a stiff finger with permanent disability

the permanent disabilities which follow are of major economic importance The main principle of reduction is to bring and hold the distal fragment in alinement with the proximal fragment.

For fractures of the tufted portion of the distal phalanx evacuate the hematoma under the nail if present and apply a padded bandage to pro-

tect the end of the finger Immobilize fractures of the shaft of the bone with a hairpin splint, or apply a plaster of Paris "thimble" Occasionally it is necessary to correct angulation

Sprain fractures of the upper end of the distal phalanx ("baseball finger") produce a decided flexion deformity at the distal joint The bony attachment of the extensor tendon is torn off the phalanx, so that the flexor profundus bends the finger without resistance Treat these

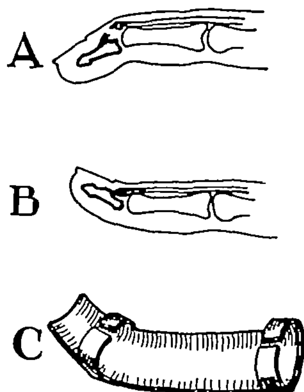


Fig 184 Drop-Finger or Baseball Finger

A note that the bony attachment of the extensor tendon to the distal phalanx has been torn off permitting the typical flexion deformity to occur B, correction. Hyperextension of the finger relaxes the extensor tendon and permits its bony attachment to unite in the normal position C splint of malleable metal which is useful for maintaining hyperextension of the finger

by applying a hyperextension splint made of sheet metal or hyperextend the joint with a tongue blade combined with a triangular block of felt Immobilize the finger in this position for six weeks

Fractures of the middle phalanx usually extend across the mid-shaft and are angulated If the fracture is distal to the insertion of the flexor sublimus tendon there is palmar angulation, if it is proximal to the insertion of this tendon there is dorsal angulation When there is no angulation apply a bent wire splint or a circular plaster of Paris dressing to maintain slight flexion Correct palmar angulation under local anesthesia,

and apply the wire splint or plaster of Paris Correct dorsal angulation by strapping the finger to a tongue blade or use plaster of Paris. Order X ray examination after the application of the dressing and change the position if there is remaining angulation

Fractures of the proximal phalanx usually are angulated toward the palm The interosseous muscle draws the proximal fragment toward the palm and the lumbrical displaces the end of the distal fragment dorsally Apply anterior and posterior unpadded plaster of Paris splints as for fractures of the metacarpal bones, or use a small plaster of Paris bandage Always check the position by X ray examination and alter the dressing if necessary



FIG 185 PLASTER THIMBLE FOR FRACTURES OF DISTAL PHALANX
A wet strip of plaster is applied, and is molded into the desired shape as it hardens

Treat comminuted fractures and fractures extending into joints by immobilization in slight flexion Traction with a Kirschner wire driven through the terminal phalanx may be necessary (See Fractures of the metacarpal bones)

Compound fractures of the fingers need an immediate debridement. Many compound fractures require skeletal traction through the distal phalanx. (For treatment of compound fractures see Chapter III)

If infection develops use warm boric acid compresses during the acute stage and immobilize the finger in slight flexion Treat chronic osteomyelitis of the phalanges conservatively as in most instances healing occurs without the necessity of removing the bone or amputation

Follow-up treatment There is no rule for the length of immobilization

although most simple finger fractures unite firmly enough for return to average work within four weeks In many instances the patient can continue at work without disability while the finger is immobilized Give heat and massage early as prolonged edema causes fibrosis and limitation of motion After the period of splinting the entire hand should be exercised twice daily while it is immersed in warm water Parrafine baths are excellent for pain and stiffness in the hand Encourage early use of the fingers by handiwork squeezing a sponge wringing a towel and carpentry (See Physiotherapy and restoration of function, page 81) The Thilo glove is helpful for gaining flexion in stiff fingers In some instances the operation of capsulotomy in which the contracted posterior ligament of the joint is divided, is helpful for persistent limitation of flexion

Precautions These seemingly trivial injuries are important and require careful and persistent treatment Every fracture of a finger should be treated as carefully and as persistently as a fracture of the femur Use

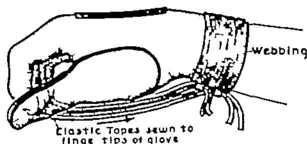


FIG 186 THILO GLOVE
This is helpful in stretching extension contractures of the fingers

the hyperextension position for all drop-finger' fractures Do an immediate debridement for compound fractures of the hand Never amputate or resect for osteomyelitis as conservative treatment although prolonged will save a finger Persistent and thorough follow up care is essential in the prevention of contractures and restoration of function If physiotherapy aggravates the pain it should be stopped

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and apply the wire splint or plaster of Paris Correct dorsal angulation by strapping the finger to a tongue blade or use plaster of Paris Order X ray examination after the application of the dressing, and change the position if there is remaining angulation

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If infection develops use warm boric acid compresses during the acute stage and immobilize the finger in slight flexion Treat chronic osteomyelitis of the phalanges conservatively as in most instances healing occurs without the necessity of removing the bone or amputation

Follow-up treatment There is no rule for the length of immobilization

CHAPTER XVII

FEMUR

Fractures of the femur are considered under the following classification (1) separation of the upper epiphysis (2) fractures in the neck of the femur (3) intertrochanteric fractures, (4) isolated fractures of the trochanters (5) fractures in the shaft

Separation of the upper epiphysis of the femur *Etiology* The upper femoral epiphysis fits on the neck of the femur as a cap and unites with the diaphysis at the eighteenth year Separation or fracture of this epiphysis occurs in adolescents in either the heavy type of youth with an endocrine disturbance of the Fröhlich type or in tall thin youths In many instances displacement occurs without a history of severe injury Epiphyseal slipping may be bilateral although it seldom is found simultaneously in both hips

Examination Simple loosening of the epiphysis or the early stage of epiphyseal displacement causes only weakness and an aching limp with partial restriction of motions at the hip In acute cases which are caused by trauma there is severe pain with external rotation and shortening of the limb Complete displacement causes pain muscle spasm shortening with external rotation and marked restriction of passive movements In some instances a soft muffled crepitation is palpable X ray examination may not demonstrate any change when the epiphysis is separated and yet not displaced but with displacement the appearance is characteristic For proper visualization of the displacement it is important to have a lateral view as well as an anteroposterior view As the epiphysis remains in the acetabulum this condition actually is a separation of the shaft of the femur from it

Prognosis In most instances displacement can be prevented by prolonged immobilization during the early or pre-slipping stage Uncorrected displacement produces an increased angulation deformity in the neck of the femur which causes chronic aching limitation of motion shortening and a limp In many instances the displacement so disturbs the circulation that absorptive changes in the nature of osteochondritis occur in the femoral head with the same symptoms

Treatment When the epiphysis is merely separated apply a plaster of Paris spica to both hips and keep the patient in bed for three months, meanwhile ordering X ray examinations to determine the position

When the epiphysis is displaced place the patient on the orthopaedic

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fracture table and under anesthesia make traction on the hip combined with abduction and internal rotation and immobilize both lower limbs in this attitude with a double plaster spica (See Use of plaster of Paris page 59.) If manipulation fails to correct the displacement open reduction with internal fixation is necessary

Follow up treatment In less severe cases remove the plaster after three months but for actual slipping even longer immobilization is indicated



Fig 189 Deformity Produced by Fractures in Neck of Femur
The entire extremity is externally rotated and adducted and shortened

the duration being determined by periodic X ray examinations Warn the patient to avoid weight bearing for many months as union at the epiphyseal line occurs slowly and early function may cause displacement

Fractures in the neck of the femur (intracapsular fractures) *Etiology* The neck of the femur is cancellous and in advancing years becomes decalcified Such a brittle shell which must support the weight of the body is a common site of fractures Fracture in the neck of the femur is so

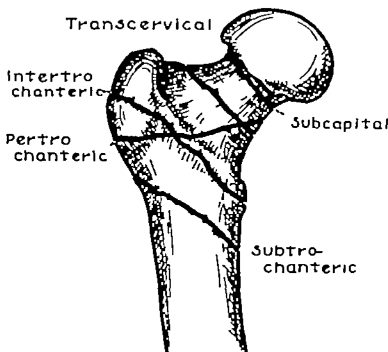


Fig 187 Fractures of the Femur
Composite diagram indicating the location of fractures which occur in the upper end of this bone



Fig 188. Epiphyseal Fracture at Upper End of Femur
Separation of the upper epiphysis producing shortening and limitation of movements at the hip joint. This is a serious condition, and requires careful attention. A lateral X ray film should be obtained routinely as this view often shows complete displacement of the epiphysis which may not be apparent in the anteroposterior view

fracture table and under anesthesia make traction on the hip combined with abduction and internal rotation and immobilize both lower limbs in this attitude with a double plaster spica (See Use of plaster of Paris page 59) If manipulation fails to correct the displacement open reduction with internal fixation is necessary

Follow up treatment In less severe cases remove the plaster after three months but for actual slipping even longer immobilization is indicated,



Fig 180 Deformity Produced by Fractures in Neck of Femur
The entire extremity is externally rotated and adducted and shortened

the duration being determined by periodic X ray examinations Warn the patient to avoid weight bearing for *many months* as union at the epiphyseal line occurs slowly and early function may cause displacement

Fractures in the neck of the femur (intracapsular fractures) *Etiology* The neck of the femur is cancellous and in advancing years becomes decalcified Such a brittle shell which must support the weight of the body is a common site of fractures Fracture in the neck of the femur is so

common in old women that it is called the "old ladies' fracture" being twice as common in women as in men it also occurs occasionally in children Why the fracture almost always occurs in the left hip has never been explained Usually it is produced indirectly by a twist in tripping over a rug or by a misstep and then the patient falls The fall itself does not cause the fracture but may produce impaction of the fragments

Fig 190a

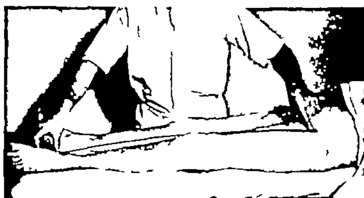


Fig 190b



Fig 190a. Measuring Length of Lower Extremity

The distance between the anterior superior spine of the ilium and the internal malleolus is compared with a similar measurement of the other limb For accuracy it is important that both extremities be held symetrically

Fig 190b Determination of Nelaton's Line

The anterior superior spine of the ilium and the tuberosity of the ischium are marked, and a line is drawn between them The tip of the greater trochanter normally lies on this line With fractures in the neck of the femur the tip of the trochanter lies above this line

Examination When an aged person cannot get up after a fall a fracture of the hip always should be suspected There is a typical deformity with broadening of the lateral outline of the hip and complete external rotation and adduction of the entire limb If the leg is rotated inward it will immediately turn over again into external rotation unless the fracture is impacted. No attempt should be made to elicit crepitus in order to corroborate the diagnosis as movements increase the pain and shock

The shortening of the lower extremity is determined by comparing on each limb the distance from the tip of the anterior-superior spine of the ilium to the internal malleolus. The greater trochanter is elevated above Nelaton's line which line is drawn from the anterior-superior spine of the ilium to the tuberosity of the ischium. Normally there is a fossa in the thigh behind the greater trochanter. This fossa is obliterated by the distal fragment, which is displaced posteriorly.

Impacted fractures in good position cause only moderate pain and partial disability, there may be no deformity and the patient may be able to walk.

X rays should be taken before the patient is put to bed in the hospital, thus preventing unnecessary movement. The line of fracture is practically transverse and is located in the upper portion of the neck (subcapital) in the middle of the neck (transcervical), or it may extend through both

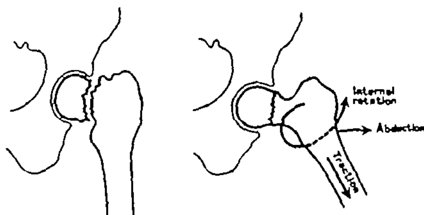


FIG 191 DIAGRAMMATIC REPRESENTATION OF INTRACAPSULAR FRACTURE
The directions of manipulation are indicated by arrows

the neck and trochanteric area (cervico-trochanteric). Impaction is not common although in this respect the anteroposterior film alone may be misleading. In addition a lateral view of the hip should be obtained as this may reveal posterior displacement of the distal fragment which cannot be seen clearly in the anteroposterior film. The distal fragment is either adducted or abducted, abduction fractures often are impacted.

Prognosis Whether or not the patient will survive depends upon the age, the general condition and the treatment. The prognosis for persons who have pronounced myocardial changes, diabetes, bronchitis and who are obese is not favorable. When the patient is kept in bed decubitus ulcers, hypostatic pneumonia and death are of common occurrence and may be difficult to prevent even by careful nursing and frequently changing the position in bed. Sphincter control is poor and psychosis may develop. Favorable results of the fracture itself depend upon early and

common in old women that it is called the "old ladies' fracture" being twice as common in women as in men, it also occurs occasionally in children. Why the fracture almost always occurs in the left hip has never been explained. Usually it is produced indirectly by a twist in tripping over a rug or by a misstep and then the patient falls. The fall itself does not cause the fracture but may produce impaction of the fragments.

Fig 190a

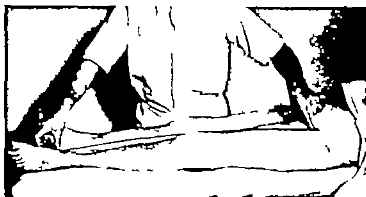


Fig 190b



Fig 190a MEASURING LENGTH OF LOWER EXTREMITY

The distance between the anterior superior spine of the ilium and the internal malleolus is compared with a similar measurement of the other limb. For accuracy it is important that both extremities be held symetrically.

Fig 190b DETERMINATION OF NELATON'S LINE

The anterior superior spine of the ilium and the tuberosity of the ischium are marked and a line is drawn between them. The tip of the greater trochanter normally lies on this line. With fractures in the neck of the femur the tip of the trochanter lies above this line.

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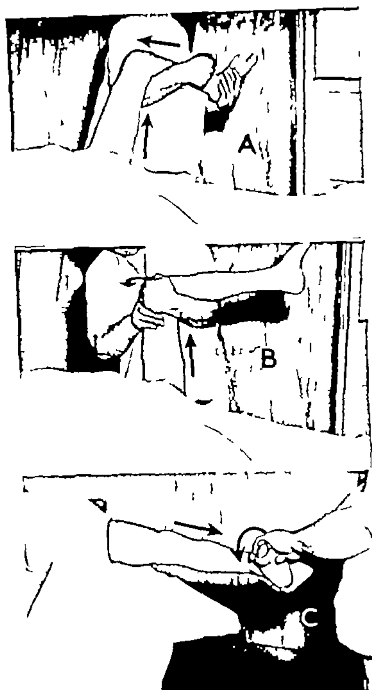


FIG 102. LEADBETTER'S REDUCTION OF INTRACAPSULAR FRACTURES

A flexion of the knee and hip with traction upward, to correct the posterior displacement of the distal fragment. B traction combined with internal rotation the limb gradually being straightened out C internal rotation combined with abduction to hold the fragments reduced

lation is to place the distal or manageable fragment in apposition to the proximal or unmanageable fragment Use Leadbetter's modification of the Whitman method as follows Stand on a low stool and flex the hip and

accurate reduction followed by secure fixation Statistics of treatment by immobilization combined with prolonged bed treatment indicate a large percentage of deaths and non unions Most of the blood supply to the head of the femur is derived from the trochanteric area For this reason non union is commonest after fractures close to the head of the femur and least common after fractures near the trochanters When there is pronounced displacement obviously the capsular ligament has been torn and the slight circulation from this source also is lost As new capillaries must form across the neck of the femur accurate reduction and complete immobilization are absolutely necessary for repair of this fracture Several forms of internal fixation recently devised have reduced the mortality rate to about 12 per cent by permitting early activity and the incidence of non union also has been reduced Intracapsular fractures unite slowly and crutches must be used for a long time in many instances for an entire year after the injury Non union causes permanent disability with shortening of the limb and instability in most cases the patient must be resigned to the permanent use of crutches unless the general condition permits an operation Solidly impacted fractures unite in a relatively short time

Treatment This fracture is one of the most difficult to manage both from the aspect of the patient and of the local condition Apply Russell s traction for all cases immediately in order to eliminate pain and to reduce the fracture (See Traction page 67) Make a careful survey of the patient s general condition and give stimulants if necessary There usually is some shock and over treatment should be avoided Emphasize the importance of careful nursing Many of these patients lack control of the bladder for at least the first few days and the bed should be kept dry and the back should be kept powdered

As soon as the general condition is favorable the fracture should be given further attention The choice must be made between (A) external immobilization by plaster of Paris and (B) internal fixation by a flanged nail or screws The plaster method can be used by the general practitioner but necessitates prolonged treatment in bed with the probability of general complications and a high percentage of non union On the other hand internal fixation has great advantages but this operation should not be attempted by the general practitioner or novice in bone surgery With this there is complete fixation of the fragments without the necessity of external support, and the patient is enabled to get out of bed and use crutches soon after injury Firmly impacted fractures do not require immobilization or internal fixation and the early use of crutches without weight bearing is advised

Reduction of fractures in the neck of the femur The principle of manipu

rubbing of the plaster bandages The patient lies upon the orthopaedic fracture table While assistants continue to make gentle traction on both limbs in moderate abduction and internal rotation draw a snugly fitting piece of stockinet down over the chest and abdomen and likewise cover the thighs and legs Fasten a thin layer



FIG 194 DOUBLE PLASTER SPICA FOR INTRACAPSULAR FRACTURES

For adequate immobilization the plaster should extend to the knee of the unaffected limb Ropes of plaster or a wooden stick are incorporated in the spica for additional strength and this also facilitates handling the patient Immobilizing both hips permits trimming the plaster low over the abdomen thus enabling the patient to sit in bed and thereby preventing hypostatic pneumonia

of felt around the upper portion of the chest and around the pelvis and apply sheet cotton bandages to the limbs First make a thick reverse of plaster bandage for the lower back and thigh and over this roll the plaster bandages The plaster must fit snugly over the felt and should be rubbed continually in order to avoid wrinkles and make the cast strong Then add extra reverses of plaster to the groin and across the buttocks as the plaster bandages are being applied The plaster should

knee to right angles In this position make continuous traction upward upon the thigh with one arm while maintaining internal rotation and adduction lifting up the distal fragment with the other hand placed under the greater trochanter Then circumduct the limb into internal rotation and abduction and finally extend the hip and knee It is important that the femur be internally rotated before it is abducted The heel palm test in which the operator supports the patient s heel in the palm of his hand is not always dependable If the foot continues to point upward reduction is complete however in many instances after reduction of the fracture the limb will turn immediately into external rotation unless the foot is held in the upright position The limb should be held continuously



FIG 193 TYPICAL INTRACAPSULAR FRACTURE BEFORE AND AFTER REDUCTION
The first film shows the distal fragment displaced upward and adducted The prominence of the lesser trochanter denotes external rotation The second film shows reduction after upward traction, internal rotation and abduction

in internal rotation while antero-posterior and lateral X ray views are obtained and until the fragments have been fixed by plaster or operation If the films do not show complete reduction the manipulation should be repeated

A *Immobilization with plaster of Paris* The use of plaster of Paris in maintaining abduction and internal rotation as advocated by Whitman has many disadvantages Absolute immobilization is lacking because there is movement of the atrophied limb inside the plaster spica. Further more the distal fragment tends to gravitate posteriorly on account of the softening which occurs in the opposing surfaces of the fracture

Directions for applying a double plaster spica for fractures of the hip It is important that the plaster be strong and yet light in weight The operator should have sufficient assistance in the making of reverses and in the application and continuous

to the other with additional plaster bandages This form of plaster spica permits the patient to sit nearly upright in bed (See Use of plaster of Paris page 59)

B *Internal fixation* Debility and advanced years are indications and not contraindications for internal fixation as this form of treatment immobilizes the fracture while the patient's strength is sustained and complications are avoided by activity Obviously the fracture first must be reduced completely A variety of fixation materials may be used the flanged nail devised by Smith Petersen being most popular The hip is exposed and the nail is hammered in the entire operation being checked



FIG 107 INTRACAPSULAR FRACTURE UNUNITED
Note the upward displacement and adduction of the distal fragment and complete absorption of the neck

by portable X ray examinations The author's method of inserting two parallel screws subcutaneously under fluoroscopic guidance is rapid and accurate No splints or external immobilization are required after internal fixation

Follow-up treatment When a double plaster spica is used the patient should sit upright in bed and can be lifted into a wheelchair thus preventing hypostasis An overhead frame with a trapeze is fastened to the bed as an aid to the patient in changing position After three months a short plaster spica is applied and the patient commences to use crutches By the addition of a ½ inch lift to the heel and sole of the shoe on the opposite foot it is easier for the patient to clear the floor with the affected limb Do not permit weight bearing until the end of six months or even longer

extend from the lower rib border to the web of the toes on the affected limb and to the knee of the other limb Change the water in the plaster bucket at least once for if it becomes saturated with plaster the bandages will not absorb enough water Do



FIG 195 INTERNAL FIXATION OF FRACTURE IN NECK OF FEMUR
Complete reduction followed by the insertion of two screws This method permits early movements without immobilization

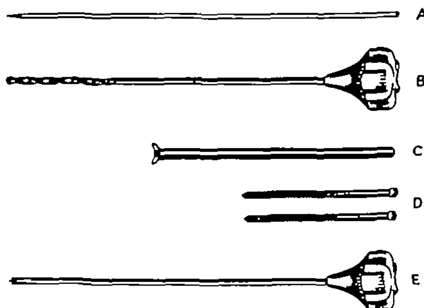


FIG 196 AUTHOR'S INSTRUMENTS FOR INTERNAL FIXATION
These can be used for intracapsular fractures, and for intertrochanteric and pertrochanteric fractures A, guide pin for determining plane of the femoral neck. B drill C cannula, for protecting muscles from drill and for holding the screws during their insertion. D stainless steel screws with modified Phillips head E screw-driver to fit screw heads

not permit the assistant to hold the patient's heel and avoid any dents in the plaster as these cause pressure sloughs Next trim the plaster at the web of the toes and in the groin and *buttocks and cut it away over the abdomen as far as* the umbilicus including the stockinet and cotton with a few additional turns of plaster bandage Last of all strengthen the spica by fastening a stick or plaster rope from one knee

5 During convalescence give personal instruction in the use of crutches
6 Warn the patient to avoid bearing weight upon the limb until X ray examinations show firm union

Intertrochanteric fractures of the femur (extracapsular fractures) These fractures are outside the capsule of the hip joint and extend between the greater and lesser trochanters in many instances being comminuted They are distinctly different from fractures in the neck of the femur as to their cause prognosis and treatment They occur more often in men than in women and never are seen in young adults The usual cause is a direct injury as a fall on the side of the body, with resulting severe pain, swelling and ecchymosis The entire limb is in a helpless attitude of externa

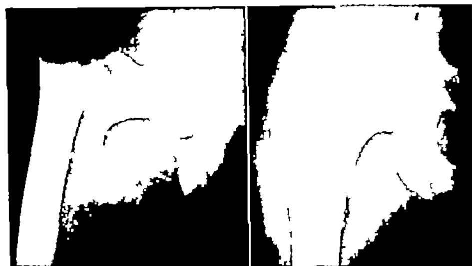


FIG 199 INTERTROCHANTERIC (PERTROCHANTERIC) FRACTURE
Before and after the application of Russell s traction The separation of the fragments was corrected by removing two pounds of the weight Union after traction for ten weeks

rotation with shortening and the lateral outline of the hip is broadened The mortality rate with average treatment is considerably higher than for intracapsular fractures As this portion of the femur has an abundant blood supply fractures here usually unite, and within twelve weeks As with fractures in the neck of the femur stimulation attention to the patient s general condition and good nursing are important On account of the action of the adductor and gluteus maximus muscles which cause decided angulation and external rotation deformity some form of continuous traction is the generally accepted form of treatment Russell's traction is satisfactory for overcoming the shortening of the limb but may not control the external rotation of the distal fragment therefore although there may be no shortening the patient will walk with the limb

depending upon the extent of union as determined by X rays (See Use of crutches page 84) Give heat and massage for atrophy of the muscles and for stiffness at the knee joint (See Physiotherapy page 81)

When internal fixation is used only a short period of hospitalization is necessary as crutches may be used after a few days With this method the general condition is aided by activity strength is preserved and stiffness of the joints is prevented The patient is not permitted to bear weight on the limb until the end of six months or even longer depending upon the extent of union as determined by periodic X ray examinations It should be remembered that these fractures unite endosteally without evidence of external callus in the X ray films

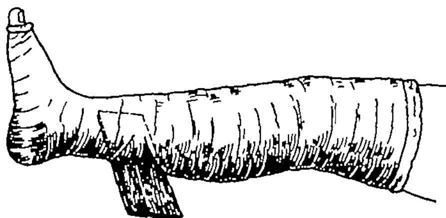


Fig 198. Preventing Rotation of Limb in Bed
A wooden splint is fastened to plaster of Paris which is applied to the foot and ankle or leg, after removal of a plaster spica for fractures of the hip

When fractures in the neck of the femur fail to unite an operation is advisable providing the patient is strong enough The type of operation depends upon the individual case

Precautions It is important to save the life of the patient and at the same time to secure firm union in the hip To accomplish these, give careful attention to the following details

1 Impress upon the nurse the importance of cleansing and dusting the skin, and of frequently shifting the position to avoid bed sores The patient should be turned twice daily and should use a back rest for part of the time for the prevention of hypostatic pneumonia

2 Either reduce the fracture and apply a double plaster spica as soon as the condition of the patient permits or

3 Advise internal fixation which operation should not be delayed

4 Give careful attention to the general condition of the patient stimulating when necessary

these fractures must be treated by Russell's traction or skeletal traction through the tibial tubercle An alternate method is fixation by two of the author's strong 5-inch stainless steel screws



FIG 201 RESULT OF INTERNAL FIXATION OF HIP
This aged patient with a comminuted intertrochanteric fracture was standing out of bed two days later

Isolated fractures of the trochanters Fractures of the greater or lesser trochanter are uncommon The greater trochanter alone may be broken by direct violence the line of fracture being oblique or comminuted

Occasionally in adolescents the epiphysis of the lesser trochanter is torn off by sudden contraction of the iliopsoas muscle in violent exercise as jumping without marked displacement

turned outward. The most satisfactory form of traction is obtained by inserting a Steinmann pin in the tubercle of the tibia; this must be placed parallel to the patella in the transverse axis of the limb to prevent external rotation of the limb. With skeletal traction fairly firm union occurs in about eight weeks. Meanwhile the patient should exercise, and a back rest may be used if the foot of the bed is raised sufficiently for counter traction. (See Traction, page 67.) Traction should be continued until X-ray examination shows callus formation. By this time the patient can lift his heel off the bed, which indicates that union is firm enough to permit the use of crutches. Plaster of Paris should be avoided, as it weakens the



Fig. 270. Intertrochanteric (Pertrochanteric) Fracture.
Before and after internal fixation with 5-inch stainless steel screws (author's method). No splinting or traction is necessary.

patient and even a snugly fitting double spica cannot control the muscle contraction which produces shortening and deformity.

In most instances this form of fracture can be treated successfully by internal fixation with Moore pins or with two of the author's long stainless steel screws. Such an operation saves many lives, also permits the early use of crutches and reduces the expense of prolonged hospitalization. (See Treatment of fractures in the neck of the femur.) This procedure should not be attempted by the general practitioner.

Pertrochanteric fractures. The line of fracture is oblique and is distal to the intertrochanteric fracture level, with the lesser trochanter broken off and displaced. As the outer surface of the upper portion of the distal fragment is thin and cannot be held by ordinary forms of internal fixation

these fractures must be treated by Russell's traction or skeletal traction through the tibial tubercle. An alternate method is fixation by two of the author's strong 5-inch stainless steel screws.



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Isolated fractures of the trochanters. Fractures of the greater or lesser trochanter are uncommon. The greater trochanter alone may be broken by direct violence, the line of fracture being oblique or comminuted.

Occasionally in adolescents the epiphysis of the lesser trochanter is torn off by sudden contraction of the iliopsoas muscle in violent exercise as jumping, without marked displacement.

turned outward The most satisfactory form of traction is obtained by inserting a Steinmann pin in the tubercle of the tibia this must be placed parallel to the patella in the transverse axis of the limb to prevent external rotation of the limb With skeletal traction fairly firm union occurs in about eight weeks Meanwhile the patient should exercise and a back rest may be used if the foot of the bed is raised sufficiently for counter traction (See Traction page 67) Traction should be continued until X ray examination shows callus formation By this time the patient can lift his heel off the bed, which indicates that union is firm enough to permit the use of crutches Plaster of Paris should be avoided as it weakens the



FIG 200 INTERTROCHANTERIC (PERTROCHANTERIC) FRACTURE
Before and after internal fixation with 5-inch stainless steel screws (author s method) No splinting or traction is necessary

patient and even a snugly fitting double spica cannot control the muscle contraction which produces shortening and deformity

In most instances this form of fracture can be treated successfully by internal fixation with Moore pins or with two of the author s long stainless steel screws Such an operation saves many lives also permits the early use of crutches and reduces the expense of prolonged hospitalization (See Treatment of fractures in the neck of the femur) This procedure should not be attempted by the general practitioner

Pertrochanteric fractures. The line of fracture is oblique and is distal to the intertrochanteric fracture level with the lesser trochanter broken off and displaced As the outer surface of the upper portion of the distal fragment is thin and cannot be held by ordinary forms of internal fixation

dents and in many instances are followed by deformity and permanent disability. Most of the fractures are transverse and are due to severe direct violence although sudden torsion may break the bone in a spiral direction, and occasionally there are multiple fractures. In war extreme violence may produce compound injuries and traumatism to other parts of the body.

Examination. The patient is shocked and in most instances there is a marked deformity. The thigh is extremely swollen and usually shortened by muscle contraction which produces angulation or over riding of the fragments. In adults there may be as much as four inches shortening.

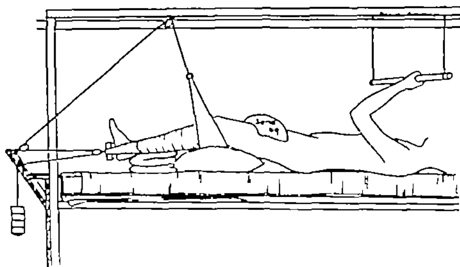


FIG 203 RUSSELL'S TRACTION FOR FRACTURES IN SHAFT OF FEMUR

The foot of the bed is elevated with blocks. A pillow is placed lengthwise under the knee and leg. The end pulleys must be on a line with the leg. The angle between the upper portion of the rope and the leg should be 90 degrees and the angle between the leg and mattress should be 15 degrees. The amount of pull obtained is 2½ times the weight applied.

On account of the severe pain caused by movements attempts to elicit crepitus should be avoided. As soon as emergency treatment has been given X ray examination should be made of the entire femur in both anteroposterior and lateral views to determine the nature of the fracture and decide upon the treatment.

Prognosis. With careful attention a good result can be obtained in most instances although perfect anatomical reposition and complete motion are unusual. A satisfactory anatomical result depends upon securing apposition of the fragments without shortening and without angulation maintaining the normal anterior curve of the shaft and avoiding any rotational deformity. A satisfactory functional result implies restoration of normal strength with full motions in the joints of the limb

These injuries cause moderate pain and a decided limp and the patient is unable to flex and adduct the hip The exact nature of the condition is determined only by X ray examination Fractures of the greater trochanter may be immobilized in moderate abduction with a short double plaster spica and *fractures of the lesser trochanter also may be immobilized*



FIG 202 INEXPENSIVE WALKER FOR CONVALESCENCE
This is useful for aged patients who have fractures of the lower limbs

in moderate flexion with a short double plaster spica The plaster is removed six weeks later at which time callus is firm enough for weight bearing However in many instances rest in bed with a back rest and a pillow placed under the knee is equally satisfactory

Fractures in the shaft of the femur *Etiology* Fractures of the shaft are common in all ages except in the less active older persons These severe injuries are usually the result of automobile and industrial acci

Keller Blake splint is not available immobilize with a long board extending from the axilla to the ankle Give morphine and hot fluids and apply external heat for shock and as soon as possible transfer the patient to a

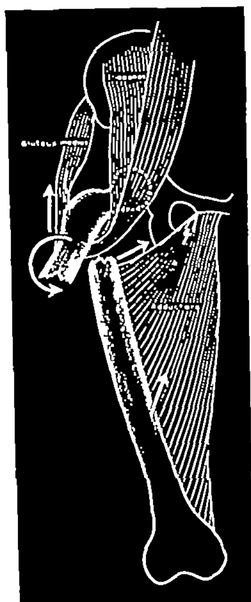


FIG 205 TYPICAL SUBTROCHANTERIC FRACTURE
Arrows indicate the displacing effect of the muscles

hospital Examine the patient for associated injuries and apply traction immediately (For treatment of compound fractures see Chapter III)

Treatment of fractures in the shaft of the femur in infants Immobilize the limb for four weeks by means of a long plaster of Paris spica maintaining the hip and knee in flexion

and without instability or ligamentous strain from deformity In children fractures of the femur unite in an average of two months and seldom cause permanent deformity or disability The shortening from moderate overlapping in children is not serious as it is compensated by overgrowth in the length of the limb before maturity Most fractures in adults do not unite for three months or longer and total disability lasts about six months *Permanent partial disability is common being due to shortening angulation* and limitation of joint motions Angulation often produces strain and pain in the knee, with the subsequent development of arthritis As

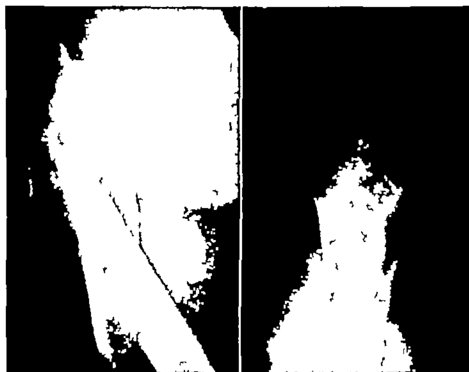


FIG 204 COMMINUTED SUBTROCHANTERIC FRACTURE
There is decided shortening of the limb Before and after reduction by Russell s traction

little shortening as one half inch may produce a limp and decided shortening produces chronic backache from strain Limitation of motion in the knee is a common sequel to these fractures, although for most industrial purposes a man is not disabled if he can flex his knee to a right angle Irregularity of the joint surface after fracture of the condyles produces traumatic arthritis with permanent pain and disability

General treatment All femur fractures are serious emergencies Do not move these patients unnecessarily and splint em where they lie Apply a Thomas splint and temporary traction by fastening a bandage to the ankle and over the shoe before moving the patient If a Thomas or

Treatment of fractures in the shaft of the femur in children These fractures are transverse or spiral and are located in the middle of the shaft In small children apply Bryant's suspension only to the affected limb for maximum traction In older children apply Russell's traction, with elevation of the foot of the bed for counter traction (See Traction, page 67) Continue the traction for four weeks or until manipulation and portable X ray examinations show firm union

Treatment of fractures in the shaft of the femur in adolescents Use Russell's traction, and elevate the foot of the bed for countertraction If this



FIG 208 FRACTURE OF FEMUR IN CHILDHOOD
Before and after treatment Reduced and immobilized by Bryant's perpendicular adhesive traction

fails to correct gross overriding skeletal traction should be applied The Steinmann pin or Kirschner wire used for this should not be inserted through the epiphysis on account of interference with growth Continue the traction until manipulation and periodic X ray examination with a bedside unit demonstrate firm union (See Traction page 67)

Treatment of fractures in the shaft of the femur in adults

(1) Fractures in the upper third With fractures below the lesser trochanter the upper fragment is held flexed by the iliopsoas muscle and externally rotated by the gluteus maximus The lower or manageable fragment must be placed in alinement with the upper unmanageable



FIG 206 SUBTROCHANTERIC FRACTURE (PAGET'S DISEASE)
Before and after Russell s traction for six weeks Although it is difficult to reduce transverse fractures in this portion of the femur by any form of treatment abundant callus usually forms and the results are satisfactory providing the angulation is corrected by traction

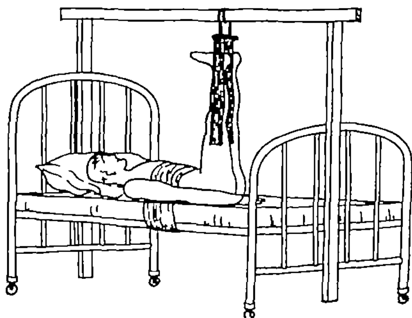


FIG 207 BRYANT S SUSPENSION FOR FRACTURES OF THE FEMUR
This treatment is satisfactory for children
Adhesive plaster is applied to one or both limbs holding the buttock slightly off the bed The body may be held to the bed by pinning a swathe to the draw-sheet



FIG 210 FRACTURE IN THE SHAFT OF THE FEMUR
Before and after the application of Russell's traction

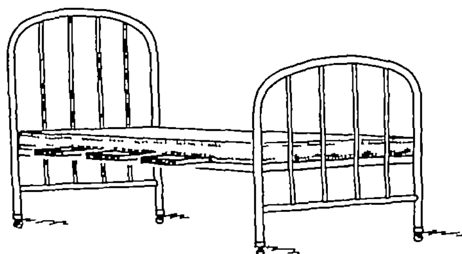


FIG 211 USE OF BOARDS IN BED
Boards are placed crosswise between the mattress and spring of the bed to prevent sagging This addition is necessary in the treatment of fractures of the femur by traction and for cases wearing plaster jackets and spicas

fragment Apply skin traction upon the lower fragment, keeping it in alinement with the upper fragment by flexion and external rotation at the hip suspending the limb in a Thomas splint with a Pearson attachment for flexion of the knee If this method fails to correct the position of the fragments apply Russell s traction These fractures are



FIG 209 OVERRIDING FRACTURES IN THE SHAFT OF THE FEMUR
This fracture in a child is compared with that in an adult
The result in the child will be satisfactory, as the shortening will be compensated by subsequent growth of the limb The result in the adult is permanent shortening a limp and disability

difficult to manage on account of angulation and overlapping and skeletal traction through the tibial tubercle combined with a Thomas splint in the same position may be necessary (See Traction page 67)

(2) Fractures in the middle third Fractures in this portion of the femur do not have uniform displacement The strong muscle contraction usually produces decided overlapping and even if the fragments are



FIG 214 GRISWOLD'S TRACTION FOR SUPRACONDYLAR FRACTURES
Note the Steinmann pin inserted in the tibial tubercle for skeletal traction and anterior traction on the lower fragment by a loop of canvas



FIG 215 FRACTURE OF LOWER FEMORAL EPIPHYSIS

end to-end, and weight of the limb causes posterior angulation Place boards under the mattress and apply Russell s traction, using from eight to ten pounds weight This is efficient safe and is not followed by stiff ness in the knee or ankle The foot of the bed must be raised to a height



Fig 212 Supracondylar Fracture
The displacing effect of the muscles is indicated by arrows

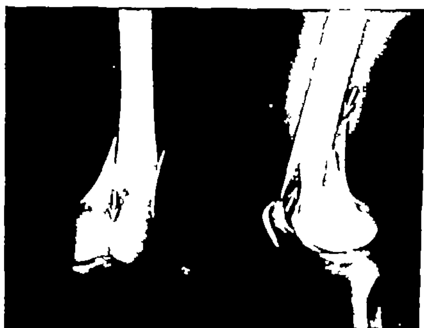


Fig 213 Supracondylar Fracture of the Femur
The sharp end of the proximal fragment pierced the skin thus producing a compound fracture Satisfactory alinement was secured by Russell s traction

of two feet for counter traction, and details of the traction must be watched carefully The result will be satisfactory if by this treatment there is not more than one-half inch shortening (See Traction page 07)

When there is more than one half inch overlapping after a trial of Rus sell s traction *for three days the treatment should be changed* to skeletal



FIG 214 CRISWOLD'S TRACTION FOR SUPRACONDYLAR FRACTURES
Note the Steinmann pin inserted in the tibial tubercle for skeletal traction and anterior traction on the lower fragment by a loop of canvas



FIG 215 FRACTURE OF LOWER FEMORAL EPIPHYSIS

traction by a Steinmann pin or Kirschner wire inserted through the tubercle of the tibia Persistent anterior angulation of the fragments can be corrected by laying a sandbag on the dorsum of the thigh (See Traction page 67) Inspect the traction daily and be certain that the patella points upward to prevent rotational deformity also preserve the normal anterior curve in the bone (For treatment of compound fractures see Chapter III)

(3) Fractures in the lower third There is a tendency to persistent angulation and the fragments often are comminuted Apply Russell s



FIG 215a. TRANSFIXION OF FEMUR

Steinmann pins drilled through the femur while the limb was held in Russell s traction have been encased in plaster of Paris to produce fixed traction The result shown in the second film enabled the patient to sit in a wheel-chair the day following this procedure

traction elevating the foot of the bed for counter traction A change to skeletal traction through the tibial tubercle may be necessary

With supracondylar fractures the proximal fragment is displaced anteriorly and the distal fragment is rotated posteriorly by the calf muscles The popliteal structures may be damaged by the posterior displacement of the sharp distal fragment Apply Russell s traction immediately placing one or two folded pillows under the knee The foot of the bed should be raised for counter traction and boards should be placed under the mattress If a portable X ray examination does not show satisfactory

reposition, insert a Steinmann pin or Kirschner wire through the tibial tubercle keeping the knee flexed with the pillows or on a Braun Böhler splint (See Traction, page 67)

Follow up treatment Order X ray examinations at regular intervals It is important to examine and adjust the traction daily, and personal

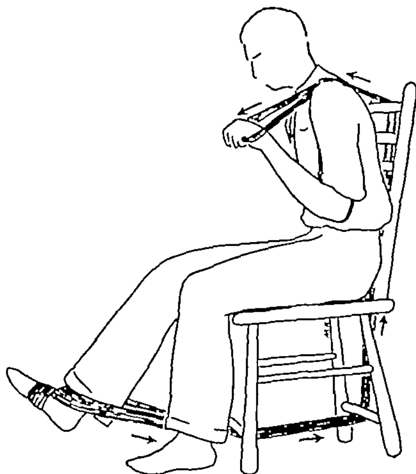


Fig 216 Kellogg Speed's Exercise

Useful for stretching the knee when extension contracture exists after injury or immobilization Such gradual stretching does not interfere with union as the patient stops pulling before strain is made on the callus This method also can be used with the patient sitting on the side of the bed

attention should be given during the convalescent period Do not remove the traction from the thigh until the fracture feels firm to manipulation and keep the patient in bed until union is complete Do not permit the weight of the limb or a sagging bed to cause posterior angulation of the fragments bearing in mind the normal anterior curve in the shaft of the femur Do not be misled by the apparent firmness of union of femur fractures while in traction Test these by manipulation with the weight

removed Another test for union is the patient's ability to lift his entire limb off the bed Although the application of a plaster spica or Thomas caliper brace will enable the patient to use crutches and leave the hospital earlier, neither of these is advisable on account of the resulting stiffness of the knee and atrophy of the limb

Encourage early function in the knee, flexing it by elevation with pillows, and instruct the patient to exercise it by traction with a loop of bandage passed around the foot Also instruct the patient in exercising his quadriceps extensor muscle When crutches are used a lift of one-half inch on the sole and heel of the shoe on the opposite foot will help the patient to clear the floor more readily with the injured extremity Do not hurry the patient into bearing weight on a fractured femur as he will walk of his own accord when it does not cause pain and feels secure to him (See Use of crutches, page 84) Forced flexion of the knee is not only useless but may cause angulation or delayed union

Precautions First treat the patient for shock Whenever possible, apply a Thomas or Keller Blake splint for temporary traction until the patient has reached the hospital and a complete examination has been made Do not manipulate a fractured thigh except to correct angulation, until you have seen the X ray films Success with traction depends upon attention to details and daily watching The foot of the bed must be raised sufficiently to prevent the weight from drawing the patient's feet against it and thus losing the effect of the traction Attendants should be instructed not to remove the traction weights under any circumstances Mark the center of the patella as a reminder to keep the knee pointing upward and thus prevent rotational deformity at the fracture Encourage early flexion of the knee during convalescence but do not apply passive movement as this may cause angulation of the fragments For best functional results avoid plaster casts

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CHAPTER XVIII

BONES OF KNEE

Separation of the lower epiphysis of the femur The lower femoral epiphysis does not become united with the diaphysis until the twenty first year and before that time separation may occur by violent force There is frequently an associated diaphyseal fracture This injury causes marked swelling at the knee and loss of function and is characterized by a soft rubbing crepitus With displacement the shaft lies posterior to the epiphysis and may cause serious damage to the popliteal structures. Interference with subsequent growth of the femur is common and may result in a knock knee or bow leg deformity *Unless manipulated without delay* the early formation of callus will prevent reduction and failure to replace the epiphysis will result in retarded growth of the limb

Give anesthesia and first aspirate the blood from the knee to facilitate reduction Manipulate by traction and acute flexion combined with forward pressure on the diaphysis

If unable to replace the epiphysis insert a Steinmann pin or Kirschner wire through the tibial tubercle for continuous traction with the knee held in flexion These cases are difficult to treat and open reduction may be necessary Repeated attempts by manipulation should be avoided on account of damaging the epiphysis After reduction plaster of Paris should be applied to the flexed knee After six weeks this is removed and the knee is permitted to relax gradually into the extended position (See Use of plaster of Paris page 50)

Fractures of the femoral condyles. These fractures are caused by severe direct force which splits the lower end of the femur and often produces injury to the interior of the knee joint The line of fracture usually extends vertically between the condyles and in some instances a T fracture is formed by its combination with a supracondylar fracture

There is marked swelling and hemorrhage in the joint with generalized tenderness and widening of the knee and complete disability Limitation of motion in the knee joint is common after these injuries especially with uncorrected displacement and there is a long period of disability

Aspirate the blood in the knee joint and manipulate without delay *Give anesthesia and apply traction and countertraction* producing lateral compression manually or with a C-clamp as an assistant makes traction on the flexed knee and then apply felt padding and plaster of Paris while the joint is held partially flexed The clamp-and plaster method must be

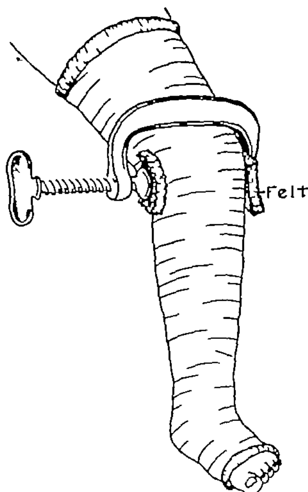


FIG 217a COMPRESSION OF FEMORAL CONDYLES

Compression and molding of spreading fractures involving the condyles of the femur with a C-clamp Felt padding must be used during this compression for protection from pressure

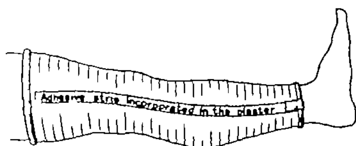


FIG 217b NON-SLIP CIRCULAR PLASTER

This is useful for the support of minor fractures and sprains of the knee The adhesive strips on the sides of the limb prevent the plaster of Paris from slipping down over the ankle

used with care as more than a reasonable amount of compression will cause necrosis of the soft tissues (See Use of plaster of Paris page 59)

Operative reduction and fixation with a screw or bolt is necessary if manipulation is unsatisfactory It is important to prevent bow leg or knock knee deformity from displacement as either of these causes permanent disability from strain and traumatic arthritis When plaster of Paris is used, remove it after eight weeks and apply a Thomas knee brace, en

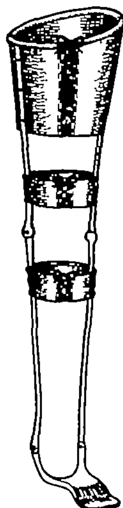


Fig 218 Brace for Protection during Convalescence
This is useful after fractures of the condyles of the femur and tuberosities of the tibia A shoe is worn over the foot plate of this brace

couraging gradual movements (See Physiotherapy page 81) Do not permit weight-bearing before the end of the third month

Sprain fractures of the condyles Avulsion of a small portion of either femoral *condyle may occur when the lateral ligament* on one side of the knee is forcibly stretched by adduction or abduction of the leg This injury is more common on the inner border of the knee

Diagnosis is made by the presence of localized pain and swelling lateral mobility, and weakness of the knee the area of tenderness is not over the middle of the ligament but is over the condyle In treating sprain fractures support the knee in the extended position with a circular plaster of Paris case extending from the groin to the ankle and permit the patient to walk without crutches (See Use of plaster of Paris page 59) Remove the plaster of Paris after six weeks and apply adhesive strapping or an

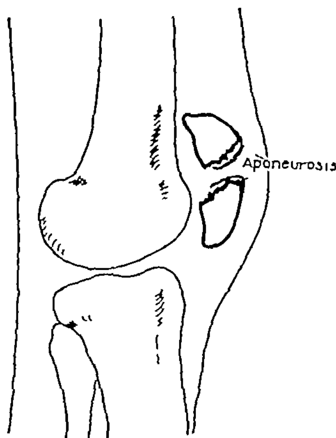


Fig 210 Typical Transverse Fracture of Patella
Note the inverted edges of the torn aponeurosis which prevent osseous union unless removed from between the fragments

ACE bandage also give heat and massage The patient should wear shoes with low and broad heels to prevent subsequent strain on the ligaments and should not engage in athletics until the following season

Fractures of the patella. *Etiology* The patella is a sesamoid bone in the quadriceps tendon It has no periosteum being covered by the fibrous aponeurosis of the quadriceps Most fractures of the patella occur in male adults and are caused by either direct or indirect force Transverse fractures are produced indirectly by sudden muscular contraction with the knee partly flexed Comminuted fractures on the other hand, are

Operative reduction and fixation with a screw or bolt is necessary if manipulation is unsatisfactory It is important to prevent bow leg or knock knee deformity from displacement as either of these causes permanent disability from strain and traumatic arthritis When plaster of Paris is used remove it after eight weeks and apply a Thomas knee brace en-

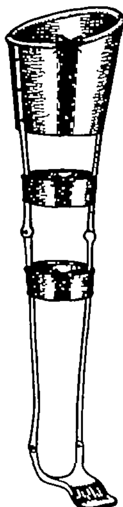


FIG 218 BRACE FOR PROTECTION DURING CONVALESCENCE
This is useful after fractures of the condyles of the femur and tuberosities of the tibia
A shoe is worn over the foot plate of this brace

couraging gradual movements (See Physiotherapy page 81) Do not permit weight-bearing before the end of the third month

Sprain-fractures of the condyles. Avulsion of a small portion of either femoral condyle may occur when the lateral ligament on one side of the knee is forcibly stretched by adduction or abduction of the leg This injury is more common on the inner border of the knee

cause considerable pain Most fractures of the patella cause disability for physical work for three months The duration of disability however depends to a considerable extent upon the manner of fixation When absorbable suture material is used prolonged immobilization is necessary When the fragments are secured with heavy wire the return of function is much more rapid as immobilization is not required

Treatment For direct fractures without displacement keep the knee straight and immobilize for eight weeks with a circular plaster dressing extending from the ankle to the groin During the entire period of convalescence the patient must be instructed in exercising the quadriceps muscle to prevent weakness Voluntary flexion is encouraged after the



Fig 221



Fig 222

Figs. 221 and 222 Comminuted Fracture of the Patella

Anteroposterior and lateral views This fracture was produced by direct violence Open reduction and fixation with soft wire was followed by early function and complete recovery

period of immobilization but passive flexion should be avoided because of the danger of disturbing union (See Physiotherapy page 81)

Open reduction and fixation is indicated for all fractures with separation and traumatic surgeons no longer consider it necessary to wait for several days before operating Aseptic technic is extremely important After the clotted blood has been removed the edges of the fracture are sutured together with heavy catgut or alloy wire according to the surgeon's choice The fragments must be brought together without interposition of the torn fascia and it is important that lateral tears in the capsule be repaired as re-fracture is due to failure to attend to these details After fixation with absorbable suture material the knee must be immobilized in complete extension for eight weeks and further follow-up care as after non-operative

caused by direct force as the impact of the flexed knee against the instrument panel or front seat of automobiles in collisions ("dashboard" fractures)

Examination The joint is distended and upon palpation of the floating fragments a characteristic ballottement is elicited

When the fracture is transverse the fragments may be separated as widely as two inches by the hemorrhage in the joint and with this displacement there is an accompanying tear of the capsule on both sides of the patella. The lower fragment is held in place by the patellar tendon but the upper fragment is drawn upward by the contraction of the quadriceps muscle *In this form of fracture voluntary extension of the knee is impossible because the quadriceps cannot pull upon the leg*



FIG 220 FRACTURE OF THE PATELLA
Before and after fixation with rustless steel wire This method permits early active movements of the knee a few days after the operation. The use of wire eliminates a great portion of the disability which follows the prolonged immobilization necessary when absorbable suture material is used

In the direct form the fragments are comminuted although not markedly separated as in many instances the aponeurosis over the patella and the capsule on each side are intact and prevent wide displacement There may be accompanying contusions and lacerations and occasionally the injury is compound X ray examination should be ordered after every severe injury to the knee to determine the exact nature of the fracture Often unsuspected fractures are discovered only in this way

Prognosis Comminuted fractures without separation unite in a relatively short time If the fragments have been widely displaced they will not unite for several months with operation the prognosis for bony union and function is favorable Unless this wide separation of the fragments is corrected by operation the gap between the fragments will be filled only by heavy fibrous tissue consequently the knee will be weak and the patient will have difficulty in getting out of a chair and in climbing stairs Malunion with irregularity of the articular surface of the patella may

cause considerable pain Most fractures of the patella cause disability for physical work for three months The duration of disability, however depends to a considerable extent upon the manner of fixation When absorbable suture material is used prolonged immobilization is necessary When the fragments are secured with heavy wire the return of function is much more rapid, as immobilization is not required

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treatment must be given When the fragments are held together with heavy wire the patient is encouraged to exercise his knee in both flexion and extension immediately after the wound has healed immobilization is not necessary and thus the period of disability is greatly reduced Order periodic X ray examinations, however do not prevent the patient from using the knee because the films fail to show callus as often bony union is not evident for several months (For treatment of compound fractures see Chapter III)

Fractures of the tibial spines The tibial spines and the crucial ligaments attached to them provide some of the anteroposterior stability of the knee joint although the greater part of the strength is due to the capsular ligaments Severe force may result in either a tearing of the



Fig 223 Vertical Fracture of the Patella

This form of fracture usually is detected only by X ray examination as there is no lack of continuity in the quadriceps extensor mechanism. Treatment is conservative

ligaments or fracture of a tibial spine The cause of this fracture is violent rotation of the leg on the fixed thigh or rotation of the thigh on the fixed leg the spine of the tibia being sheared off by the edge of the condyle of the femur

There is severe pain with marked distension of the knee on account of accumulation of blood and traumatic synovitis The loose fragment may produce crepitus and locking on movements A test for laxity of the joint is made by pressing backward and forward on the upper end of the tibia while the knee is held flexed at a right angle over the side of a table If there is abnormal movement damage also to the capsular ligaments must have occurred X ray examination should be ordered after every severe injury of the knee and may be the only means of making the diagnosis

When the fragment is not displaced immobilize the knee in the extended

position with a circular plaster of Paris dressing and forbid weight bearing for six weeks If the fragment is displaced conservative treatment is in effective, and it must be removed as it will not unite and will cause perma nent disability

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CHAPTER XIV

BONES OF LEG

Fractures of the tuberosities of the tibia. *Etiology* The upper portion of the tibia is broad and cupped to articulate with the femoral condyles Its surfaces are smooth for free motion, and the tibia must be in direct alinement with the femur for normal function The tuberosities of the tibia are fractured by severe direct force applied to the side of the leg when the knee is held in the extended position These injuries usually occur in pedestrians who are struck by automobiles (bumper fractures) One or both tuberosities may be involved fracture of the external tuberosity being the more common The line of fracture extends upward split ting and spreading and in some instances there is comminution In severe fractures of the external tuberosity the internal lateral ligament is torn and frequently there is an accompanying fracture of the semilunar cartilage The head of the fibula also may be broken

Examination There is marked pain and swelling in the knee and upper portion of the leg the knee joint is distended with blood, and there often is angulation deformity Passive movements cause aggravation of the pain The characteristic feature of this fracture is the marked lateral instability which permits the leg to be abducted or adducted on the thigh In most instances the X ray film show depression and often a squashing of the external tuberosity or of both tuberosities

Prognosis Many of these injuries are followed by permanent limitation of motion and pain from traumatic arthritis and irregularity of the articu lation Unreduced fractures of the tuberosities cause knock knee or bow leg deformity according to which side of the tibia is depressed, with in stability and consequent pain Impaction and comminution of both tuberosities cause shortening of the leg Operation usually is necessary for the severely depressed fractures of one tuberosity

Treatment Remove the blood from the knee joint by aspiration repeating the aspiration if it reaccumulates When there is no displace- ment *avoid any form of immobilization and encourage active movements* Reduce displaced fractures as soon as most of the swelling has subsided usually on the third or fourth day after injury Angulate the knee into the attitude of a marked bow leg for fractures of the external tuberosity or the attitude of a knock knee for the internal tuberosity to provide room for decompression of the tuberosity As the limb is held in this manner make lateral pressure on the sides of the tibia with clenched hands or a

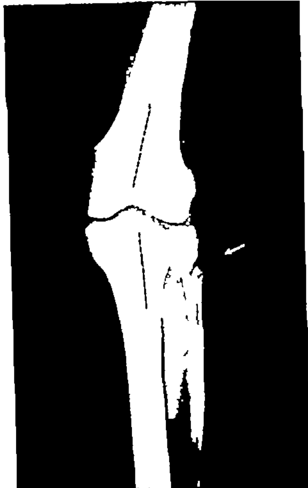


Fig 224 Fracture of the External Tuberosity of the Tibia

Unless it is corrected the knock knee angulation resulting from the comminution and compression of the tuberosity produces permanent deformity and pain This injury often can be treated satisfactorily by compression followed by immobilization in plaster in a bow leg position

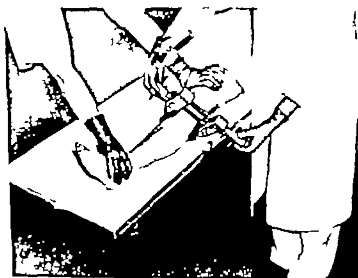


Fig 225 Correction of Spreading Fractures of External Tuberosity

A carpenter's clamp is used for compression The soft tissues must be protected with felt Note the bow leg position maintained during the reduction

C-clamp When the clamp is used the leg must be protected with blocks of felt and the external popliteal nerve near the head of the fibula should be avoided Then while still maintaining the bow leg or knock knee position, apply a circular plaster of Paris dressing with felt padding placed over the tuberosities (See Use of plaster of Paris, page 59) The plaster must be held firmly until it sets For uncorrected spreading fractures and extensive comminution or compression of the tuberosities operation is necessary and is performed best through a window cut in the plaster which has been applied beforehand



Fig 226 Comminuted Spreading Fracture of Upper End of Tibia
This fracture involves the knee joint with a fracture of the fibula The patient was struck by the bumper of a truck This form of fracture is accompanied by extreme swelling and hemarthrosis It requires prolonged immobilization which usually is followed by decided limitation of motion

Follow-up treatment Permit the patient to use crutches after two weeks but continue the immobilization in plaster for two or three months as solidification occurs slowly Then apply a caliper brace to protect the knee from lateral strain for three months longer Also for fractures of the external tuberosity the inner border of the shoe may be elevated with a leather wedge A majority of patients having comminuted fractures in the upper end of the tibia should not be permitted to walk without a brace for six months as these fractures unite slowly Give physiotherapy for swelling and limited motion and encourage voluntary flexion (See Physiotherapy and motions page 81)

Precautions Do not immobilize when there is no displacement In order to avoid permanent disability these fractures must be completely reduced Use the clamp-and plaster method with care padding the knee with felt as more than a moderate amount of pressure over the tuberosities produces a slough Encourage early active movements, and prevent edema during convalescence by the application of an Unna's paste dressing or an Elastoplast bandage

Separation of the tibial tubercle Fracture or epiphyseal separation of the tibial tubercle in adolescents is caused by blows or sudden strong contraction of the quadriceps There is local swelling and tenderness at the

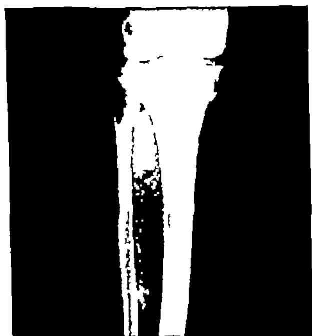


FIG 226a FRACTURE OF BOTH TIBIAL TUBEROSITIES
Such fractures without gross deformity can be treated satisfactorily by early movements without immobilization

attachment of the patellar tendon with pain on extreme movements of the knee In moderate cases apply criss-cross adhesive strapping with the knee completely extended In severe cases use plaster of Paris extending from the ankle to the groin (See Use of plaster of Paris page 59) Permit weight bearing throughout the treatment but support the knee for eight weeks In many instances traumatic separation is simulated by Osgood-Schlatter disease or epiphysitis of the tubercle

Fractures in the shafts of the leg bones. *Etiology* The shaft of the tibia extends from the tubercle to the ankle joint and normally is straight The center of gravity passes from the tip of the patella through the tibia to the middle of the ankle and thence to the interval between the second

and third toes although in persons with bow legs and knock knees there is a considerable variation It should be remembered that the fibula does not enter into the knee joint and it is not a weight bearing bone

Fractures of both bones of the leg are common, and are caused by either direct or indirect violence Indirect force or torsion causes spiral fractures of the tibia, the fibula usually being left intact In children almost all fractures occur in the middle of the leg with little or no displacement When the tibia alone is fractured the intact fibula acts as a splint and prevents gross displacement although when both bones are broken overlapping of the fragments is common Most severe fractures of the leg in city accidents occur in pedestrians who are struck by automobiles The typical "bumper fracture produced by the modern pleasure car occurs in the middle of the leg and on account of the nature of the violence severe damage to the soft structures is common In adults many fractures of the leg are compound due to the nature of the injury the superficial position of the tibia, and the sharpness and angulation of the fragments These wounds are produced directly by impact or indirectly by the sharp fragment being forced through the skin Compound fractures of the leg are especially common in war and usually are extensively comminuted by the bomb and shell explosions

Examination Fractures of the leg are accompanied by shock and cause extreme pain With linear fractures the only signs may be swelling ecchymosis and tenderness With displacement the diagnosis is plainly evident by deformity shortening abnormal mobility and crepitus When the line of fracture is oblique unless prompt attention is given the sharp proximal fragment which is displaced anteriorly may project through the skin and thus form a compound fracture There usually is severe hemorrhage with compound fractures When the lower portion of the tibia is broken by indirect force the fibula may be broken in its upper portion and for this reason X ray examination should always include the entire length of the leg as well as the knee and ankle joints

Complications Delayed union and non-union after severe fractures of the leg are common and are caused by incomplete reduction inadequate fixation, impairment of blood supply and infection Thrombosis may cause persistent edema of the leg and thrombophlebitis may occur The hematoma which accompanies severe fractures may become infected and sloughing is common after severe direct injuries as by automobiles

Prognosis A large proportion of fractures of the leg are followed by prolonged and often permanent disability A satisfactory result depends upon accurate approximation of the fragments without overlapping or angulation and avoidance of angulation deformity Shortening after complete fractures of the bones of the leg is almost inevitable except when

some of skeletal traction is used Fractures in the lower extremity require a longer period of fixation than those in the upper extremity, as they must be firmly united before bearing the weight of the body The more accurate the reposition, the earlier the union In children the period of immobilization averages two months Transverse fractures of both bones in adults need to be immobilized for an average of three months, often longer Oblique fractures may require as long as six months, as unless firmly united the fragments are liable to slip after weight bearing is resumed

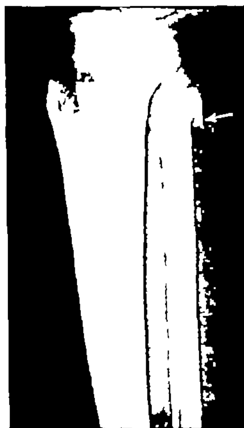


FIG 227 FRACTURE IN THE NECK OF THE FIBULA
Such a fracture does not require immobilization as no weight is borne on this bone

Limitation of motion in the ankle and knee are frequent in older patients, on account of the prolonged immobilization required Compound fractures in children almost always unite within a few months although in adults prolonged disability and non union are common Most compound fractures of the leg can be treated without amputation, the only absolute indication for this operation being complete loss of blood supply Compound fractures are especially serious in the aged on account of the lowered resistance and poor regenerative powers

General treatment Fractures of the leg are serious emergencies

Proper first aid will prevent many complications, but the limb should not be disturbed until adequate splinting and help is available. If angulated the leg should be straightened by a steady pull, and then a Thomas or Cabot splint with the addition of boards placed laterally should be applied. If stock splints are not available a satisfactory emergency splint may be made by rolling two boards in a blanket, turning the boards for a snug fit. If puncture of the skin from within by the sharp fragments appears imminent, and when there is a compound fracture, temporary traction should be applied. (For treatment of compound fractures see Chapter III.)

Patients with fractures of the lower limb never should be transported until after splinting has been applied. Hospitalization is necessary for the modern treatment of fractures of the leg. Order X-ray examination before deciding upon the method of further treatment.

Treatment of fractures of the fibula alone. Fractures in the head and upper portion of the shaft of this bone usually are caused by direct violence. With such force there may be comminution and the external popliteal nerve may be injured. These fractures do not require immobilization; after a few days of rest in bed apply an Unna's dressing or Elastoplast bandage to prevent edema and encourage early weight bearing. Involvement of the external popliteal nerve requires a drop-foot brace, and if the paralysis is permanent an operation on the ankle to eliminate use of the brace will be advisable.

Treatment of fractures of the leg without displacement. When the fracture is transverse with satisfactory alinement keep the leg under observation in the temporary splint for 24 hours, then immobilize with plaster of Paris. In young children there seldom is decided displacement, and manipulation with correction of angulation followed by the application of plaster of Paris is sufficient.

Directions for applying plaster of Paris for fractures of the leg. Let the leg lie on a pillow or table. Do not lift the limb, as this causes pain and may displace the fragments. Keep the ankle at a right angle and the knee slightly flexed, unless this position causes angulation of the fragments. Several layers of sheet-cotton may be placed over the limb, but should not be wound around on account of the liability of angulation. Plaster of Paris applied directly to the skin fits more securely, but must be used with care and must be padded around the upper portion of the thigh. *Immerse the plaster bandages in cool water to prevent fast setting.* First make a "reverse" by overlapping successive layers of plaster, two bandages being necessary for the average leg. The plaster should be dripping wet and as the reverse is made the layers should be rubbed together well. Place this reverse on the anterior surface of the limb immediately, extending from the toes to the mid thigh, and rub it gently to prevent wrinkles and for a smooth fit. After this section of plaster has hardened make another "reverse" for the posterior surface with two additional plaster bandages. While assistants hold the limb snugly to the reverse and elevate it, apply the second reverse posteriorly. This portion of the plaster also should extend from the

toes to the mid thigh. Do not permit the assistant to support the leg by the heel as flattening of the plaster causes subsequent pain and pressure necrosis. After this reverse has hardened, complete the dressing with muslin or plaster of Paris bandages.

Treatment of all other fractures of the leg. It is necessary to secure accurate reduction, to maintain this same accurate reduction, and to immobilize the fragments securely until union occurs.

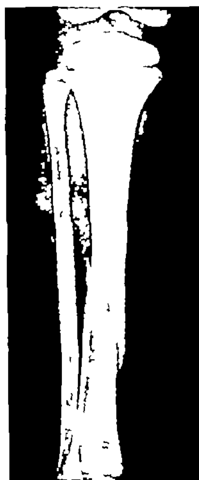


FIG. 225. FRACTURE OF THE TIBIA FROM INDIRECT VIOLENCE.
The fibula, which is intact, acts as a splint and prevents further displacement.

The most satisfactory treatment by a majority of doctors is some form of skeletal traction. Skin traction is never satisfactory for fractures in the bones of the leg. With every oblique or comminuted fracture in adults gradual overlapping will occur on account of muscle contraction unless prevented by skeletal traction. Do not be misled if the first X-ray examination does not show overriding, as almost invariably subsequent X-ray films will show progressive shortening from overriding, even if the

leg has been immobilized In order to prevent this overriding continuous traction may be made upon a Steinmann pin or Kirschner wire driven



FIG 229 IMMOBILIZATION WITH PLASTER OF PARIS

The upper illustration shows the limb bandaged with sheet cotton commencing at the web of the toes and extending to the middle of the thigh

The middle illustration shows a reenforcement strip of plaster which is molded to the posterior aspect of the limb as it hardens This splints the fragments while the remainder of the plaster dressing is being applied over it

The lower illustration shows the plaster bandages applied extending from below upwards The upper and lower borders of the sheet cotton have been turned over and incorporated in the last plaster bandage to prevent rough edges

into a bone the leg being suspended over the bed In adults the pin or wire should be placed in the os calcis at a point one and one-half inches distal to the external malleolus This location is preferable to the lower

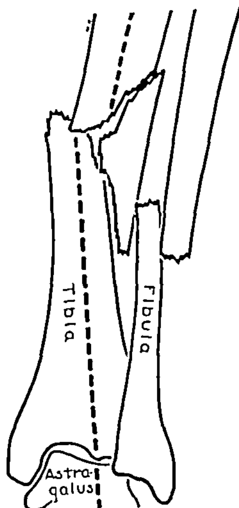


Fig 230 Bumper Fracture or Pedestrian's Fracture
This injury is common in city practice being caused by the modern automobile The triangular fragment is characteristic



Fig 231 Typical Fracture of the Leg
Note the displacing effect of the muscles and the large hematoma

end of the tibia, as the pin or wire is more easily inserted and foot-drop is prevented (See Traction page 67.) For counter traction the foot of the bed should be elevated with blocks. The leg is left undisturbed for an

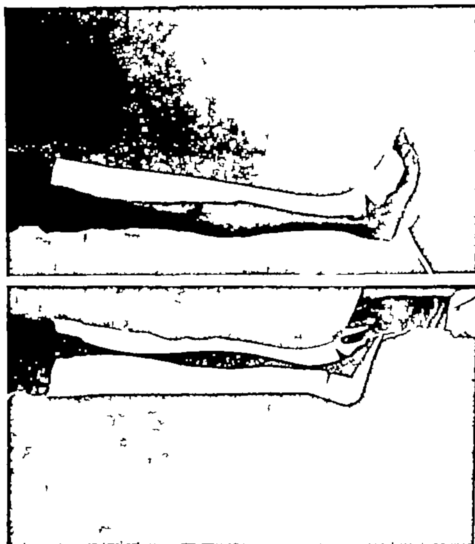


FIG 232. AUTHOR'S METHOD OF IMMOBILIZING FRACTURES OF THE LEG

The only padding used is a small piece of felt at the upper and lower portions of the cast. A thick, wet strip of plaster is applied anteriorly and directly to the skin without moving the limb. While this hardens a second strip of plaster is made. Then the limb is raised, being held to the anterior plaster splint while the second strip is applied posteriorly. As these reverses harden they are molded to fit smoothly. The cast is completed by the application of two or three plaster of Paris bandages.

average period of eight weeks during which the details of traction must be observed daily. Then the pin or wire is removed and plaster of Paris is applied. (See Directions for applying plaster of Paris for fractures of the leg, page 252.)

Transfixation is a combination of fixed traction by Steinmann pins placed in the proximal and distal fragments and immobilization by plaster of Paris. Traction is made under anesthesia by placing the leg in a frame and making a mechanical pull on the pin which has been driven into the

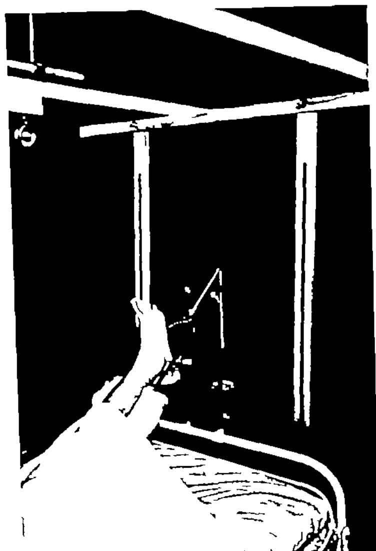


FIG 233 SKELETAL TRACTION FOR FRACTURES OF THE LEG

A Steinman pin has been inserted in the os calcis, and to this a Böhler stirrup is attached. Insertion of the pin through the heel maintains a right-angle position at the ankle. The limb is suspended in a Thomas splint

lower end of the tibia or into the os calcis. After reduction has been accomplished and checked by a portable fluoroscope or X ray films the entire limb including the pins is encased in unpadded plaster of Paris. The limb must not be removed from the reduction frame for several minutes after the plaster has hardened. Crutches may be used at once



FIG 234 TRANSFIXION OR FIXED TRACTION FOR FRACTURES OF THE LEG

After reduction of the displacement in a screw traction frame plaster of Paris is applied and includes the two stainless steel traction pins Corks are placed over the sharp ends of the pins for protection

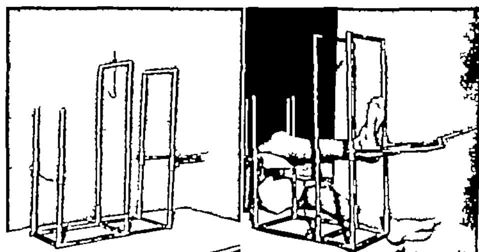


FIG 235 BÖHLER APPARATUS FOR TRANSFIXION

The length and height of the frame are adjustable A pin is passed through the os calcis and another pin is passed through the tibial tubercle and then the limb is placed in the frame Traction is made by turning a wing nut at the end of the frame with counter traction on the flexed knee The reduction is checked by X ray or fluoroscope examination and then plaster of Paris is applied over the limb including the pins which are covered with corks As soon as the plaster has hardened the limb is removed from the frame and crutches may be used Transfixion must not be attempted by the novice although its advantages are so obvious that some form of this apparatus should be in the equipment of every physician who treats major fractures

The pins or wires are removed after eight weeks and fresh unpadded plaster is applied This method is very effective and eliminates the prolonged hospitalization which is required by skeletal traction with weights and suspension in bed but must not be attempted by the novice on account of its technical details Strict asepsis must be observed as infection is disastrous In using any form of traction it is important to avoid separation of the ends of the fragments by over pull as this may cause non union



FIG 236 FRACTURE OF LEG TREATED BY TRANSFIXION
Before and after The second film shows complete reduction It is important to avoid distraction (over pull) with any form of skeletal traction as this may cause non-union

Open reduction and fixation with a stainless steel plate and screws may be performed only by competent surgeons

Compound fractures of the leg require immediate operation (See Chapter III) After the operation it usually is necessary to insert skeletal traction or internal fixation may be selected

Follow up treatment Order periodic X ray examinations while plaster is worn it is difficult to determine the extent of union but it is important to check the position of the fragments It is necessary to change the plaster at the end of six weeks because the limb shrinks as the edema

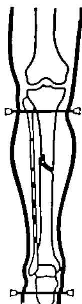


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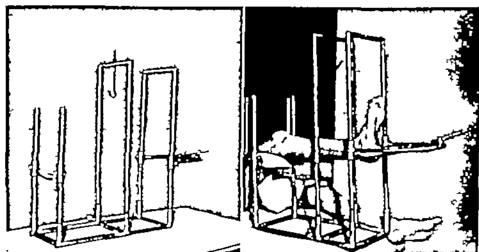


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and extravasation of blood subside and atrophy of the muscles occurs on account of inactivity. Bivalve or split the plaster for removal, and advise X ray examination to see the amount of callus. Handle the limb



FIG 237 TRANSFIXION (FIXED TRACTION)
This treatment eliminates prolonged hospitalization as the patient may use crutches soon afterward

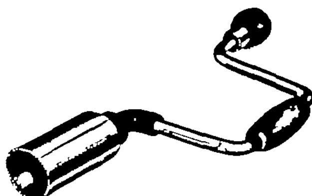


FIG 238 USEFUL TOOL
This modified trephine is a time-saver for removing a section of plaster of Paris around the transfixion pins

gently to avoid disturbance of healing. Then apply another similar plaster of Paris cast of the same length being careful to prevent angulation at this time. When there is delayed union in transverse fractures the

plaster may be replaced by a short leg brace provided with a stiff leather cuff which is laced snugly over the fracture area. Daily percussion on the heel is also useful for delayed union. (See Treatment of delayed union, page 88.) Following removal of plaster of Paris apply an Unna's "boot" (see Technic of applying Unna's boot, page 87) or apply an Elastoplast bandage to the extremity to prevent swelling. After prolonged immobili-



FIG 239 FRACTURE OF THE LEG WITH RESULTS OF TRANSFIXION
The second film shows complete reduction. The third film shows fairly firm union at the end of three months. Complete recovery at the end of six months.

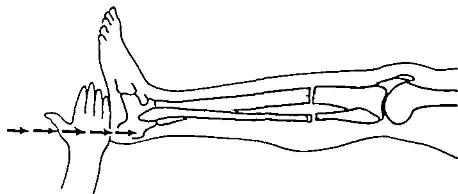


FIG 240 PERCUSSION TREATMENT OF DELAYED UNION
The leg rests upon a flat surface while the heel is struck 50 times twice daily with short choppy blows.

zation the ankle and foot are weak and should be supported by adhesive strapping. Do not permit the patient to wear bedroom slippers but insist that he wear shoes to avoid foot-strain. A grafting operation is necessary for non-union.

Precautions. When the fragments are in satisfactory alinement be careful to prevent displacement while applying plaster of Paris. Never

cover a limb with plaster if blebs are present, as these indicate severe damage to the soft structures and the leg should be observed daily Elevate the foot of the bed to avoid pronounced edema. Order X ray reexamination periodically throughout the course of treatment as a check on the position of the fragments and progress in union Except when there is absolutely no displacement of the fragments all oblique fractures in adults should be treated by skeletal traction Never attempt to make traction by adhesive plaster as skeletal traction is the only form of pull which is satisfactory Careful technic must be observed for the insertion of the skeletal traction as infection is serious Give prolonged immobilization for fractures of the leg as insufficient support is the most common

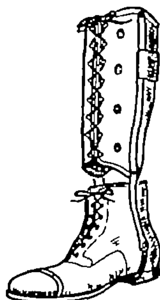


FIG 241 BRACE FOR CONVALESCENCE
This is a useful support for delayed union
The stiff molded leather cuff is laced tightly around the area of fracture

cause of mal union and non union Warn the patient to use crutches until you have determined by firm manipulation and X ray examination that the fracture has become completely united regardless of how well the leg may feel to him Prevent edema after removal of plaster of Paris by applying an Unna s paste dressing or an Elastoplast bandage routinely Passive motions of the knee and ankle may delay union or cause angulation

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CHAPTER XX

BONES OF ANKLE

In considering fractures which extend into the ankle joint there are certain anatomical facts which should be remembered The lower ends of the tibia and fibula are bound together by the strong inferior tibiofibular ligament forming a mortise between the internal and external malleoli for the rocking motion of the astragalus in flexion and extension The movements of abduction or eversion and adduction or inversion are in the subastragalar joint and not in the ankle The internal lateral ligament which connects the internal malleolus and tarsal bones is strong and thick, the external lateral ligament extending from the external malleolus to the foot is thin composed of three bands and frequently is torn

Etiology When extreme force is applied to the foot it is transmitted through to the astragalus and the tibiofibular mortise and as a consequence the ligaments are torn or a fracture or dislocation occurs Most ankle fractures are caused by indirect violence as sudden twists and falls in the standing position Fractures of the ankle occur by (1) external rotation of the foot (2) abduction or eversion (3) adduction or inversion (4) hyperflexion (5) hyperextension and (6) compression force of the foot on the leg The comminuted type of fracture in the lower articular surface of the tibia is usually caused by extremely severe direct violence as in being run over by a vehicle Extreme force may produce fracture-dislocation and compound injuries are not uncommon

Examination The patient has severe pain and cannot walk There is marked swelling which occurs soon after the injury on account of hemorrhage and effusion within the ankle joint and deformity is common In most instances there is abnormal mobility and crepitus may be present There is point tenderness although it is not always possible to distinguish between the tenderness over the tear in a ligament and that over a fracture Accurate diagnosis depends upon X ray examination Exposures should be made in both anteroposterior and lateral directions and also may be made in an oblique plane X ray examination is advisable after every injury of the ankle even if there appears to be only a sprain

Prognosis If the displacement has been corrected and the ankle has been immobilized properly there is seldom any permanent disability Unless the normal ankle mortise is restored there will be instability and chronic pain The average time of immobilization is six weeks although

more severe fractures require a somewhat longer time Under the ordinary treatment there is still further disability after the period of immobilization, on account of muscular weakness and edema Early protected weight bearing by the use of an unpadded walking-cast however greatly reduces the period of disability and prevents troublesome edema Fractures of the ankle in older persons often cause permanent pain limitation of motion and disability on account of traumatic arthritis Articular fractures may cause chronic pain and disability



Fig 242 Bleb Formation
When multiple blebs form soon after injury they denote severe injury of the soft tissues including the vessels It is important to watch for complications

General treatment A pillow or blanket rolled over two narrow boards in the form of a scroll may be used for temporary splinting Reduce and immobilize fractures of the ankle immediately without waiting for the swelling to subside If there has been extensive injury to the soft structures with bleb formation however the limb should be elevated for several days before immobilization in plaster Local or general anesthesia may be used complete relaxation being necessary for manipulation Visualize the displacement and treatment by looking at the X ray films A circular plaster of Paris cast is the most satisfactory form of immobilization for most of the cases The Böhler unpadded walking-cast is especially valuable as it permits function while protecting the fracture but this should be applied by only those who have had considerable experience in plaster technic (For treatment of compound fractures see Chapter III)

CHAPTER XX

BONES OF ANKLE

In considering fractures which extend into the ankle joint there are certain anatomical facts which should be remembered The lower ends of the tibia and fibula are bound together by the strong inferior tibiofibular ligament forming a mortise between the internal and external malleoli for the rocking motion of the astragalus in flexion and extension The movements of abduction or eversion and adduction or inversion are in the subastragalar joint and not in the ankle The internal lateral ligament which connects the internal malleolus and tarsal bones is strong and thick the external lateral ligament extending from the external malleolus to the foot is thin composed of three bands and frequently is torn

Etiology When extreme force is applied to the foot it is transmitted through to the astragalus and the tibiofibular mortise and as a consequence the ligaments are torn or a fracture or dislocation occurs Most ankle fractures are caused by indirect violence as sudden twists and falls in the standing position Fractures of the ankle occur by (1) external rotation of the foot (2) abduction or eversion (3) adduction or inversion (4) hyper flexion (5) hyperextension and (6) compression force of the foot on the leg The comminuted type of fracture in the lower articular surface of the tibia is usually caused by extremely severe direct violence as in being run over by a vehicle Extreme force may produce fracture-dislocation and compound injuries are not uncommon

Examination The patient has severe pain and cannot walk There is marked swelling which occurs soon after the injury on account of hemor rhage and effusion within the ankle joint and deformity is common In most instances there is abnormal mobility and crepitus may be present There is point tenderness although it is not always possible to distinguish between the tenderness over the tear in a ligament and that over a fracture Accurate diagnosis depends upon X ray examination Exposures should be made in both anteroposterior and lateral directions, and also may be made in an oblique plane X ray examination is advisable after every injury of the ankle even if there appears to be only a sprain

Prognosis If the displacement has been corrected and the ankle has been immobilized properly there is seldom any permanent disability Unless the normal ankle mortise is restored there will be instability and chronic pain The average time of immobilization is six weeks, although

malleolus and continues upward and outward through the astragalus to fracture the fibula about two inches above the tip of the malleolus. There is a typical deformity which consists of abduction or partial outward displacement of the foot on the leg. The entire ankle is extremely swollen and there is tenderness over the inner border of the joint, with even greater tenderness a short distance above the external malleolus.



FIG 245 MANIPULATION OF POTT'S FRACTURE
Note the pressure and counter pressure without inversion of the foot

Reduce Pott's fractures without delay using local or general anesthesia. While an assistant keeps the knee flexed for relaxation of the calf muscles adduct the foot and make pressure upon the outer side of the ankle with one hand as counter pressure is made on the inner and lower portion of the leg with the other hand. It is not necessary to twist or sharply invert the foot. If the normal contour of the joint has not been restored abduct the

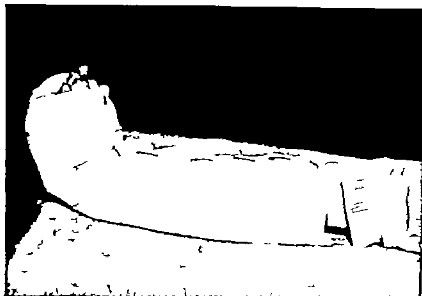


FIG 243 GURD PILLOW SPLINT FOR TEMPORARY IMMOBILIZATION

This is used for fractures in the lower leg and ankle and provides compression for severe edema. Note that the foot is held upright by tucking in the corners of the pillow

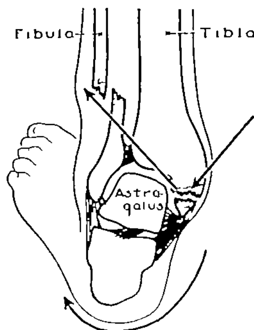


FIG 244 MECHANISM OF POTT'S FRACTURE

This fracture is frequently accompanied by a fracture of the internal malleolus The arrows denote the leverage mechanism of the injury There is a marked valgus deformity The inferior tibio-fibular ligament is intact

Pott's fracture occurs by leverage which forcibly abducts the ankle This force ruptures the internal lateral ligament or breaks the internal

Bimalleolar fractures are sometimes complicated by posterior dislocation, in some instances also a triangular portion of the posterior articular surface of the tibia is broken off and displaced to form the so-called "tri malleolar" fracture To reduce grasp the heel and pull it forward with one hand while producing backward pressure against the front of the leg Immobilize the ankle at a right angle in plaster, without either inversion or eversion The plaster should extend from the toes to the mid thigh, with the knee flexed for complete control of the ankle Accuracy of reduction is important and can be determined only by X ray examinations The posterior fragment is difficult to control and it may be necessary to insert a



FIG 247 BIMALLEOLAR FRACTURE BEFORE AND AFTER REDUCTION

The mortise is disrupted and there is an extreme abduction deformity Reduced by adduction combined with lateral pressure and immobilized in circular plaster of Paris *The second film shows the mortise and the perpendicular line of weight bearing restored*

Steinmann pin in the os calcis for manipulation and immobilization in plaster or open reduction may be advisable.

Anterior fracture-dislocation is uncommon and as it is difficult to hold the fracture reduced open reduction usually is necessary for restoration of the articular surface of the tibia

Non-union is common after displaced fractures of the internal malleolus on account of interposition of soft tissues and must be treated by operation

Comminuted fractures of the tibia Manipulate fractures extending into the ankle joint by traction and countertraction and immobilize at a right angle without inversion or eversion (See Directions for applying plaster of Paris under Pott s fracture) In many instances it is necessary to use skeletal traction through th os calcis or open reduction may be required

ankle in order to disengage the fragments and repeat the manipulation Then apply plaster of Paris to hold the ankle at a right angle, and with the foot neither inverted nor everted Check the position by immediate X ray examination

Directions for applying plaster of Paris for fractures of the ankle

An assistant should hold the ankle at a right angle Cover the entire foot ankle and leg with sheet-cotton bandage using a few extra turns around the ankle First apply a reverse for reenforcement made by overlapping successive lengths of one or two plaster bandages and shape this to the back of the limb as it hardens Then roll on plaster bandages smoothly beginning at the web of the toes and extending to the top of the calf Do not permit the assistant to support the leg by the heel as any depression in the plaster may cause discomfort and a pressure slough Flatten the

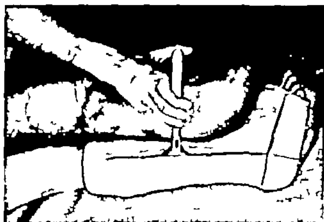


Fig 246. Plaster of Paris for Pott s Fracture

Note the right angle position of the ankle The plaster has been cut in two directions over its thinnest portion and is being opened with a spreader

plaster over the metatarsophalangeal joints and finally cut the cast down the center or bivalve it by cutting both sides By cutting the plaster while it is still moist difficulty with the circulation will be avoided and removal later is facilitated At the end of the second week when most of the swelling has subsided apply a fresh plaster cast with less padding which can be worn for the remainder of the time The patient should exercise the toes and contract the muscles under the plaster frequently during the entire period of immobilization

Fractures of the malleoli Fractures of one or both of the malleoli are caused by a severe wrench or occasionally by direct lateral shearing force Accurate reduction is important as displacement causes permanent pain and disability on account of disruption of the ankle mortise and disturbance in the line of weight bearing Treat uncomplicated fractures of the malleoli by immobilizing the ankle at a right angle with circular plaster correcting displacement by molding the plaster as it hardens (See Directions for applying plaster of Paris under Pott s fracture)

attachment of the external lateral ligament from the fibula The ankle is held in the adducted position there is local swelling and there may be slight crepitation Movements and attempts at weight bearing are painful X ray examination should be ordered after every injury of the ankle for differentiation of sprain and sprain fracture Immobilize the



FIG 250 REDUCTION OF POSTERIOR DISLOCATION AT THE ANKLE
Plaster of Paris may be applied without disturbing the counter traction bandage

ankle at a right angle in plaster with the foot neither adducted nor abducted (See Directions for applying plaster of Paris under Pott s fracture)

Rupture of the tibiofibular ligament may occur with or without fracture In some instances the condition at first appears to be an ordinary sprain of the ankle but subsequent examination on account of persistent weakness



FIG 248 FRACTURE OF ANKLE BY SHEARING VIOLENCE
The arrow denotes the direction of force There is a decided spreading of the ankle mortise This displacement is uncommon

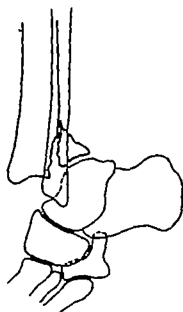


FIG 249 COTTON'S FRACTURE
Splitting and posterior displacement of the articular surface of the tibia combined with posterior dislocation

Sprain fractures of the ankle All severe twists of the ankle should be suspected of causing fractures until proven otherwise The usual sprain fracture is caused by sudden adduction of the foot which tears off the bony

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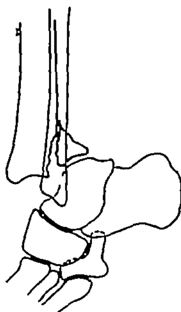


Fig 249 Cotton's Fracture
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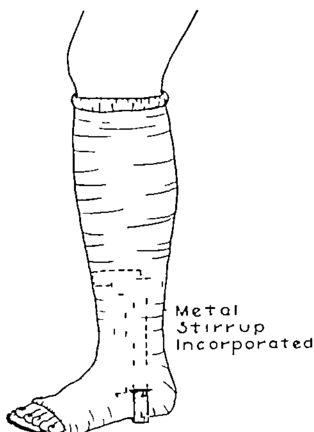


FIG 252 BÖHLER WALKING CAST FOR EARLY WEIGHT BEARING

This provides ambulatory support for fractures of the ankle and foot The plaster is applied to the bare skin the only padding being small strips of felt placed over the web of the toes and below the knee The foot never is inverted The plaster sole extends beyond the toes Note that the ankle is held at a right angle and the stirrup is close to the heel thereby enabling the patient to walk well

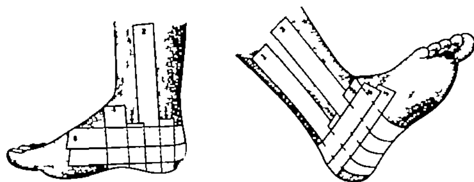


FIG 253 AUTHOR'S METHOD OF STRAPPING THE ANKLE

This is used during convalescence from sprains and for support after immobilization Strips numbered 1 and 3 beginning over the inner aspect of the ankle support the external lateral ligament Strips numbered 2 and 4 beginning over the outer aspect of the ankle support the internal lateral ligament Strips numbered 5 and 6 encircle the ankle laterally

and swelling shows a decided spreading or diastasis of the joint The broadened ankle can be restored to its normal width by squeezing it laterally with the clenched hands but as soon as the compression is released the bones spread apart again and the mortise is widened Watson-Jones has proven that this condition exists by firmly abducting the ankle during X ray examination The proper treatment is early immobilization in plaster of Paris the plaster being compressed laterally as it hardens (See Directions for applying plaster of Paris under Pott s fracture) Cases which have not been recognized early can be managed only by operation

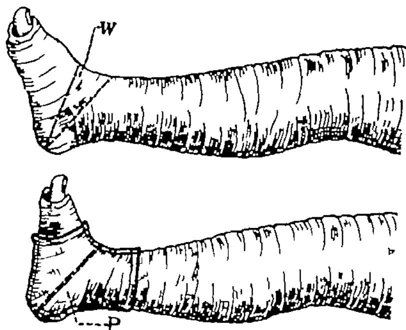


Fig 251 Method of Correcting Faulty Position at the Ankle
W wedge-shaped section of plaster to be removed in order to obtain a right angle position or to correct angulation of fractures P patching with a plaster bandage after removal of the wedge

Fractures of the lower epiphysis of the tibia The lower epiphysis of the tibia does not unite with the diaphysis until the eighteenth year, and before that age it may be separated or broken by violent force There is frequently an associated diaphyseal fracture of the tibia The epiphysis may be only loosened or it may be markedly displaced or crushed depending upon the violence and mechanism of the injury This condition causes marked swelling at the ankle and loss of function and is characterized by a soft rubbing or muffled crepitus When displaced the epiphysis is usually posterior to the diaphysis Traumatism at the time of injury or repeated traumatism in attempts at reduction may cause retarded growth of the tibia and permanent deformity at the ankle Unless manipu

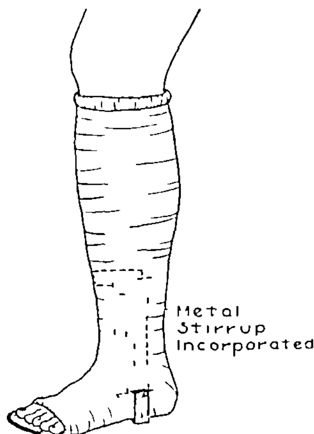


Fig 252 Böhler Walking Cast for Early Weight Bearing

This provides ambulatory support for fractures of the ankle and foot The plaster is applied to the bare skin the only padding being small strips of felt placed over the web of the toes and below the knee The foot never is inverted The plaster sole extends beyond the toes Note that the ankle is held at a right angle and the stirrup is close to the heel thereby enabling the patient to walk well

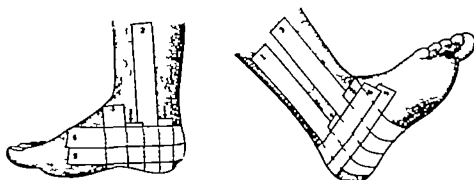


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lated without delay the early formation of callus will prevent reduction Reduce posterior displacement by pressing the tibia backward as the foot is drawn forward, as for posterior fracture-dislocations of the ankle Operation may be necessary if decided displacement exists after manipulation Following replacement the ankle should be immobilized at a right angle in plaster (See Use of plaster of Paris page 59)

Follow-up treatment Immobilize Pott s fractures in plaster for six weeks Immobilize fractures of both malleoli for eight weeks as the tendency to displacement is greater than after simple injuries of the ankle. Fractures with rupture of the tibiofibular ligament require eight weeks Immobilize sprain fractures for four weeks For epiphyseal injuries the period in plaster depends upon the amount of injury in the individual cases varying from six to twelve weeks Permit the use of crutches after the



FIG 254 FRACTURE OF INTERNAL MALLEOLUS

This could not be reduced by manipulation Open reduction was necessary The second and third films show the result of the operation and fixation with a stainless steel nail There was painless weight-bearing six weeks after the operation

first week but instruct the patient to keep the foot elevated in the horizontal position if swelling occurs The use of a walking-cast prevents muscular weakness from inactivity but this form of support is not advisable for cases with decided displacement At the end of the second week when most of the swelling has subsided apply a fresh plaster cast with less padding to be worn for the remainder of the time Request a new X ray examination after the reapplication of plaster to be certain of the position The patient should exercise the toes and contract the muscles under the plaster frequently during the entire period of immobilization After the removal of plaster of Paris the use of an Unna s dressing or boot for several weeks prevents edema and provides ambulatory support for weakness (See Technic of applying Unna s boot page 87) Prevent foot strain by the use of a strong oxford shoe immediately after the plaster is removed it may be necessary to cut the vamp and box of the shoe in order

to provide additional room for edema of the foot Give massage and order contrast baths by immersing the ankle alternately in hot and cold water twice daily (See Physiotherapy page 81) For subsequent weakness the ankle should be strapped with adhesive plaster and a three sixteenth inch wedge of leather may be added to the inner border of the heel Uncorrected displacement and residual deformity must be treated by operation Comminuted fractures extending into the ankle joint which are followed by permanent pain can be relieved only by operation to produce ankylosis

Precautions It is a serious mistake to postpone reduction because of swelling as the displacement produces edema and delayed reduction is more difficult because of the beginning formation of callus Accuracy in reduction is important, as uncorrected displacement causes permanent pain and limited motion Always immobilize the ankle at a right angle position to prevent contracture of the Achilles tendon Avoid marked adduction or inversion in immobilizing these fractures molding the plaster as it hardens for the correct position of the fragments For safety and to save time in removing the cast later bivalve it as soon as it has hardened Change the plaster at the end of two weeks as the edema has subsided and the original plaster is too loose after this time

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CHAPTER XXI

BONES OF FOOT

Fractures of the bones of the foot are considered under the following classification (1) Fractures of the astragalus (2) fractures of the os calcis, (3) fractures of the scaphoid bone (4) fractures of the cuboid bone, (5) fractures of the cuneiform bones, (6) fractures of the metatarsal bones (7) fractures of the phalanges, (8) fractures of the sesamoid bones

Fractures of the astragalus. *Etiology* These injuries are rare Minor fractures of the astragalus are caused by avulsion of the ligamentous insertions Comminuted fractures occur in the body of the astragalus and are due to a fall in the standing position from a considerable height the force being transmitted through the heel there may be squashing and impaction of the fragments Fractures through the neck of the bone usually are caused by severe wrenching injuries which may rotate and displace the fragments to produce fracture-dislocation

Examination With even minor fractures there is extreme swelling and attempts at movement and standing are painful With all major fractures *the ankle is extremely painful and swollen Compression fractures do not* produce gross deformity although when the fragments are separated they may be displaced so much as to cause pressure necrosis of the skin There is no crepitus when the fracture is compressed and impacted X ray examination should be ordered after every severe injury of the foot, even if there are no definite signs of fracture In examining the films it is important to avoid the mistake of diagnosing a supernumerary bone as a fracture

Prognosis Avulsion fractures as sprain fractures elsewhere respond favorably to immobilization for a few weeks Fractures in the body and neck of the astragalus require prolonged immobilization because they interrupt the scanty blood supply of this bone and delayed union is common Impaction causes shortening of the limb and after many severe fractures there is permanent disability from limitation of motion and pain on account of aseptic necrosis and traumatic arthritis

Treatment Immobilize avulsion fractures in plaster of Paris for four weeks With *fractures in the main portion of the astragalus without displacement immobilize the ankle at a right angle in plaster of Paris* which should extend from the web of the toes to the top of the calf (See Directions for applying plaster of Paris under Pott's fracture)

When the fragments are displaced but not squashed reduction by

manipulation under anesthesia should be attempted without delay, as the displaced fragments are apt to produce pressure necrosis of the soft tissues. Sit on the end of the operating table and place the heel in the patient's groin for counter traction, then make firm traction combined with rocking on the ankle meanwhile pressing upon the displaced fragment



FIG 255 FRACTURE OF THE ASTRAGALUS

This usually is caused by the same type of force which produces fractures of the os calcis. Displacement is difficult to correct by manipulation and non union frequently results.

with both thumbs while the ankle is plantarflexed. Then apply plaster of Paris to maintain the plantarflexed position. In most instances it is impossible to completely replace the fragments and operative fixation is necessary for a good result.

Severely comminuted fractures should be treated by immediate operation as the results of conservative treatment are very poor.

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FIG 255. FRACTURE OF THE ASTRAGALUS

This usually is caused by the same type of force which produces fractures of the os calcis Displacement is difficult to correct by manipulation and non union frequently results

with both thumbs while the ankle is plantarflexed Then apply plaster of Paris to maintain the plantarflexed position In most instances it is impossible to completely replace the fragments and operative fixation is necessary for a good result

Severely comminuted fractures should be treated by immediate operation as the results of conservative treatment are very poor

Follow-up treatment Immobilize the ankle for four months before permitting the patient to bear weight on the foot Then apply an Unna's dressing (see Technic of applying Unna's boot page 87) or an Elastoplast bandage for the prevention of edema and to provide light support A good shoe should be worn to prevent foot-strain Chronic pain from traumatic arthritis and uncorrected displacement of the fragments requires an arthrodesis operation to stiffen the ankle joint

Fractures of the os calcis. *Etiology* The os calcis is a cancellous bone which must bear a large portion of the body weight Fractures are rather common usually resulting from falls in the upright position with the



FIG 256 FRACTURE OF THE ASTRAGALUS

This is accompanied by fractures of the lower tibia and of the os calcis The second film shows the result of an astragalectomy operation which was followed by a good result

knees held straight when the person slips from a ladder fire escape or porch On account of the cancellous nature of the os calcis such fractures usually are comminuted and squashed with impaction and shortening in the height of the bone In addition there may be a fracture of the astragalus and such falls also may produce an accompanying fracture of a vertebra The main portion of the typical fracture is at the junction of its middle and anterior third the posterior section being driven upward Such displacement produces flattening and eversion of the foot with loss of the tuber angle This angle which averages 40 degrees in the foot with a normal longitudinal arch is formed by the intersection of a line drawn through the upper posterior portion of the os calcis and a line through the subastragalar (astragalo-calcaneal) joint Indirect force sometimes

produces a linear traction fracture through the posterior surface of the heel ("duck bill" fracture) the avulsion being produced by sudden contraction of the calf muscles

Examination Fractures of the os calcis cause severe pain and disability There is a boggy swelling below and posterior to the ankle often with bleb formation With comminuted fractures the heel is flattened and broadened and the limb is shortened Crepitus and abnormal mobility cannot be elicited when the fragments are impacted X ray films in several projections must be studied carefully as comminution or impaction may be overlooked (See General Directions for guidance in X ray work in



FIG 257 COMMINUTED FRACTURE OF THE OS CALCIS
Note the lines of fracture extending into the subastragalar joint Apparently the fragments are not decidedly displaced

Fractures page 16) Do not overlook the possibility of fracture in the spine

Prognosis Prolonged immobilization is necessary on account of the type of fracture and the cancellous nature of this bone and because it supports the weight of the body Most linear fractures without displacement and even comminuted fractures in younger persons are followed by little or no permanent disability although lateral movements and the normal spring in the foot may be limited In general fractures of the calcaneus produce the large average of 40 per cent permanent disability for average work on account of chronic pain and stiffness Unless the displacement and broadening of the bone under the external malleolus is corrected there will be permanent restriction of lateral motions rigid flat

foot and chronic pain Permanent total disability is common in persons of middle age on account of an associated traumatic arthritis in the subastragalar and calcaneocuboid joints, most of the pain is due to an abnormal relation of the joint surfaces of the adjacent bones on account of uncorrected deformity in the os calcis

Treatment. Single or multiple linear fractures without displacement are not accompanied by much traumatic reaction Apply an ice cap for 48 hours and then immobilise with a circular plaster of Paris dressing The foot should be allowed to drop into moderate plantarflexion, and the

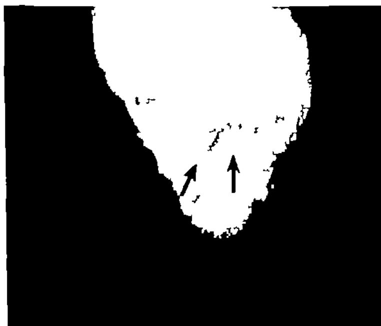


Fig 258 Anteroposterior View (See Fig 257)
Note the lateral spreading of the fragments not suspected in the other film Such extensive involvement of the subastragalar joint causes permanent pain and disability and on this account an arthrodesis operation is advisable

plaster should extend from the toes to the top of the calf A walking iron or heel may be added for early partial weight bearing in order to shorten the disability by protected function. Remove the plaster after two or three months according to the severity of the injury and encourage complete function The patient should not wear slippers on account of foot-strain The shoe should be strong with the height of the heel increased one-half inch this change prevents the entire weight from being placed on the os calcis and should be continued for two months During this time give physiotherapy for residual swelling, or use an Elastoplast dressing

In avulsion or duck beak fractures the fragment is drawn up by the



Fig 259 Compression of Lateral Spreading of Os Calcis Fracture
The soft structures are protected by thick blocks of felt as the bone is re-shaped with a C-clamp



Fig 260 Hermann's Method for Os Calcis Fractures
Traction is secured on a Steinmann pin passed through the superior portion of the os calcis while counter traction and pressure are made against the inferior part of the heel with a sawed-off crutch to restore the normal arch and salient angle

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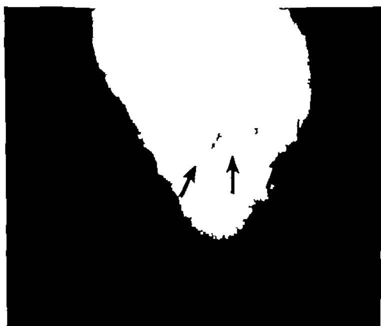


FIG 258 ANTEROPOSTERIOR VIEW (See FIG 257)

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of the foot against his chest. An X-ray examination now is ordered to show the lateral and antero-posterior outlines of the bone. This should show correction of the lateral spreading of the fragments, and the normal tuber angle should be restored. If there still is lateral spreading of the fragments, reapply the clamp for further molding. If the heel still is flattened so that the surfaces of the calcaneocuboid and astragaloscaphoid



Fig. 202. Walking Cast for Fractures of the Os calcis.

Plantarflexion of foot is maintained to prevent weight-bearing on the heel. The plaster must extend to the mid thigh with the knee slightly flexed. This permits early protected function and thus greatly reduces the period of temporary disability. It also eliminates severe permanent disability by preventing osteoporosis and degenerative changes in the joints.

joints are out of alinement there will be permanent pain and subsequent arthritis; therefore make further traction and counter traction for correction of the angular deformity and re-check the position by another X-ray examination. Finally apply sheet-cotton bandages and a circular plaster of Paris dressing with the forefoot held in a decided foot-drop position and with the knee flexed to 140 degrees. The plaster must extend from the web of the toes to the mid thigh and if a Steinmann pin

attached Achilles tendon and cannot be reduced or held by conservative treatment. A stainless steel screw is satisfactory for internal fixation on account of its superficial position the screw must be removed three months later after union has taken place. A shoe with the heel raised should be worn for the following two months during which period physiotherapy may be necessary.

With comminuted fractures of the body of the os calcis there is decided swelling and bogginess and swelling with widespread extravasation of blood around the entire heel and ankle. For this apply an ice-cap for 48 hours then use an ACF bandage combined with one or two rubber sponges for compression keeping the foot elevated for a week. Then the



FIG 261 FRACTURE OF THE OS CALCIS

Note the diminished salient angle in the first film. In the second film the normal salient angle of 40 degrees has been restored by skeletal traction and compression under anesthesia.

deformity and squashing of the heel must be corrected under anesthesia. Correct whatever impaction is present by rocking the heel from side to side and next mold the heel to correct the lateral spreading of the fragments by compression with a C-clamp or a carpenter's clamp. During this molding the sides of the foot should be protected with heavy pieces of felt and the clamp shifted and reapplied until the normal lateral outline of the heel has been restored. At this time for marked comminution and deformity insert a Steinmann pin through the superior and posterior portion of the os calcis. (For technic see Chapter VI.) Then make manual traction on the pin as the forefoot is pressed downward into the foot-drop position to correct the flattened angulated position of the fragments and thus to restore the normal long arch of the foot. For counter traction the operator presses a sawed-off crutch placed on the sole

Examination Fractures without displacement are diagnosed by pain and swelling local tenderness and pain on weight bearing If there is compression there may be an inversion deformity of the foot When the fragments are displaced they may be palpated lying in a prominent position, with deformity of the foot Accurate diagnosis may be made only by X ray examination A supernumerary or accessory scaphoid bone seen in the films should not be mistaken for a loose fragment

Prognosis Patients seldom recover from these fractures in less than three months Most severe fractures are followed by chronic pain from traumatic arthritis and crush fractures of the scaphoid may be followed by inversion deformity of the foot with limitation of movements



FIG 203 DUCK BILL FRACTURE OF THE OS CALCIS
The fragment is displaced by the pull of the tendo Achillis It is difficult to treat this fracture satisfactorily without operation There was complete recovery after internal fixation although it was necessary to remove the screw later

Treatment When there is no displacement apply circular plaster from the web of the toes to above the ankle maintaining the foot in slight inversion and the ankle at a right angle Mold the plaster around the longitudinal arch of the foot as it hardens (See Use of plaster of Paris page 59)

With displaced fractures and fracture-dislocations give anaesthesia and manipulate by everting the foot over a padded block at the same time pressing upon the displaced bone with the thumbs to replace it between the astragalus and cuneiform Immobilize the foot in circular plaster extending from the top of the calf to the web of the toes molding the plaster around the longitudinal arch Fracture-dislocations must be completely reduced open reduction often being necessary as the scaphoid forms the

has been inserted it is incorporated in the plaster As the plaster hardens it should be compressed to fit snugly over the sides of the heel and under the long arch

Follow-up treatment For comminuted fractures change the plaster every three weeks as the edema subsides and atrophy occurs Exert compression over the sides of the heel as the plaster hardens, to prevent lateral spread of the fragments under the malleoli The pin should be removed from the heel by the eighth week If the fracture is comminuted and extends into the subastragalar joint there will be limitation of inversion and eversion movements and chronic pain in a large proportion of cases In young patients conservative treatment usually is satisfactory and early protected weight bearing with the aid of a walking iron added to the plaster is encouraged until the plaster is removed twelve weeks after the injury Then an Unna s paste dressing or Elastoplast bandage is used for the prevention of edema and a corrective shoe is worn As such a condition usually causes permanent disability in older persons an arthrodesis operation should be performed six weeks after the injury Thus, by eliminating movements in the subastragalar joint, there will be no further pain and this restriction of function produces little or no permanent disability If the fracture is extremely comminuted and displaced and extends into the calcaneocuboid joint as well as into the subastragalar joint permanent disability must be expected the most satisfactory treatment for such a case is arthrodesis of these two joints and also of the astragaloscaphoid joint to prevent permanent pain obviously in such an instance the restriction of movements in itself constitutes a permanent partial disability for most forms of manual work

Precautions Suspect fracture of the os calcis after a fall in the standing position even when there is no deformity of the foot Also suspect fracture of the spine after every injury of this nature Do not manipulate the foot for several days or even apply plaster of Paris until the bogginess of the heel has subsided with rest and elevation in bed The general practitioner should not attempt treatment of comminuted fractures of the heel as these are difficult to manage and require the skill of a specialist Unless these cases are treated properly and even if the best attention is given there often will be permanent pain and disability

Fractures of the scaphoid bone. *Etiology* The tarsal scaphoid may be broken by direct or indirect violence Severe twists cause fractures with displacement (fracture-dislocations) while blows and heavy objects falling upon the foot sometimes produce comminuted fractures of the scaphoid alone or of additional tarsal bones without dislocation The scaphoid may be crushed between the internal cuneiform bone and astragalus

web of the toes to above the ankle without inversion or eversion of the foot (See Use of plaster of Paris page 59) Displacement requires manipulation under anesthesia and operation as for fracture-dislocations of the scaphoid bone may be necessary Change the plaster after two weeks, by which time most of the swelling should have subsided Remove the plaster six weeks after the injury and give heat and massage (See Physiotherapy page 81) Do not permit full weight bearing until several weeks later when local tenderness has subsided Strap the foot with adhesive plaster and order orthopedic shoes for support until the strength of the foot has been restored An arthrodesis operation may be necessary if there is persistent pain on account of traumatic arthritis

Fractures of the cuneiform bones. *Etiology* The cuneiform bones are usually broken by direct force the fracture sometimes being impacted Avulsion fractures are caused by indirect force such as violent twists

Examination Avulsion fractures cause only moderate pain swelling and tenderness With direct fractures and the accompanying severe traumatism of the soft structures marked swelling ecchymosis and tenderness and sometimes crepitation are present X ray examination always should be ordered before treating severe injuries of the foot

Treatment When there is an avulsion fracture or when the fragments are not displaced immobilize the foot in plaster extending from the web of the toes to the top of the calf molding the plaster under the longitudinal arch and metatarsal bones When the fragments are displaced manipulate the foot under anesthesia while making compression upon the fracture and then mold the plaster snugly over the dorsum of the foot (See Use of plaster of Paris page 59)

Apply fresh plaster after two weeks after most of the swelling has subsided avoiding inversion or eversion of the foot Remove the plaster six weeks after the injury and give heat and massage (See Physiotherapy page 81) Use adhesive strapping and corrective shoes during convalescence Support the more severe type of fracture with a foot plate Do not permit the patient to bear full weight upon the foot until local tenderness has subsided Chronic pain from traumatic arthritis may require an arthrodesis operation

Fractures of the metatarsal bones. *Etiology* These fractures are rather common in industry and usually are caused by direct injury which also considerably damages the soft structures of the foot The first and fifth metatarsals are more frequently injured than the other metatarsal bones as these bones are more prominent With severe injuries there may be also fractures of the tarsal bones Indirect force such as turning over on the outer border of the foot sometimes produces an oblique fracture in the proximal portion of the fifth metatarsal bone

keystone for the bony arch of the foot At the time of operation an arthrodesis is advisable to prevent subsequent displacement and chronic joint pain (For treatment of compound fractures see Chapter III)

Follow-up treatment Apply new plaster after two weeks by which time most of the swelling should have subsided, hold the foot flat while it is applied as inversion deformity produces severe pain on weight bearing Remove the plaster after eight weeks and give heat and massage (See Physiotherapy page 81) Weakness in the foot should be treated later by adhesive strapping and exercises Do not permit complete weight bearing until the fourth month when local tenderness has subsided If traumatic arthritis occurs and is not relieved by a well-made foot plate and physiotherapy finally an arthrodesis operation to eliminate the painful motion at this area will be necessary



FIG 264 FRACTURE DISLOCATION OF TARSAL BONES
Severe injuries to the tarsus usually produce a combination of fracture and dislocation

Fractures of the cuboid bone *Etiology* Fractures of the cuboid bone are caused by direct force producing comminution and sometimes impaction of the fragments When the cuboid alone is involved the fragments are seldom displaced There may be associated fractures of other tarsal bones as in the cuneiform and metatarsals or there may be a fracture-dislocation

Examination On account of the accompanying traumatism of the soft structures there is marked ecchymosis swelling and tenderness X ray examination should be ordered routinely as otherwise minor fractures may not be recognized

Prognosis These injuries cause many weeks of disability on account of persistent swelling and tenderness in the foot Many older patients complain of chronic pain and stiffness from traumatic arthritis. Severe multiple fractures in this part of the foot often are followed by deformity

Treatment Apply a circular plaster of Paris cast extending from the

tions apply circular plaster from the web of the toes to above the ankle, and mold the plaster well under the longitudinal and transverse arches. It is important to prevent a bony prominence on the dorsum or sole of the foot caused by angulation of the fragments. (See Use of plaster of Paris, page 59.)

With multiple fractures give anesthesia and manipulate while traction is made on the toes. Such fractures are accompanied by extensive swelling on account of thrombosis and edema and should not be immobilized in plaster but should be treated by incising the hematoma early, expressing the blood and using continuous warm boric acid compresses in bed.

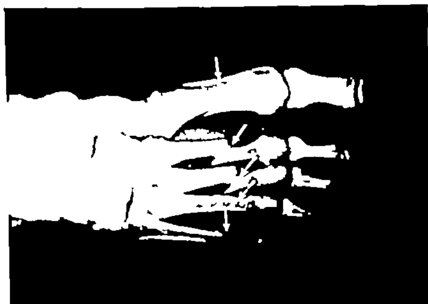


FIG 266 MULTIPLE FRACTURES OF THE METATARSAL BONES

Note overlapping of the fragments and the similarity of displacement. Such displacement unless corrected causes permanent disability on account of pressure of the fragments against the plantar nerve branches. In addition the extensive hematoma in the foot often becomes fibrotic and constricts the veins and lymphatics with resulting permanent edema and thickening.

When there is overlapping of the fragments reduction is necessary; skeletal traction by Kirschner wires and a banjo splint may be satisfactory or it may be advisable to make leverage through a small incision on the dorsum of the foot.

For linear fractures of the fifth metatarsal bone caused by turning over on the foot, apply a wooden tongue blade with adhesive plaster strapping and permit the patient to walk with a cane.

Compound fractures of the foot require immediate debridement and should be watched carefully for infection. (See Chapter III.) If infection develops keep the patient in bed and apply continuous warm boric acid compresses. Later use vaseline gauze and dress infrequently.

without displacement 'March fracture' is occasionally seen in persons of sedentary habits who have walked excessively, as new soldiers, being most common in the shaft of the second and third metatarsal bones

Examination There is extensive swelling ecchymosis and local tenderness with direct fractures If there is severe pain or crepitus when pressure upward and downward at the metatarsophalangeal joint is made the diagnosis of fracture in the metatarsal bone is fairly certain Indirect fractures in the fifth metatarsal bone and march fractures may be overlooked as there is only a small area of tenderness and the foot appears merely sprained there is no displacement of the fragments and the fracture may not be visible on the X ray film until callus begins to form X ray examination should be obtained after all injuries of the foot which cause

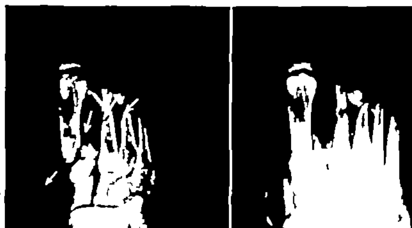


FIG 265 COMMINUTED FRACTURES OF FOOT
The second film shows the result of traction through the distal phalanx with a piece of Kirschner wire combined with a banjo splint for four weeks

persistent pain In examining the X ray films a supernumerary bone must not be mistaken for a fracture

Prognosis Fractures of the metatarsal bones which are in good position unite in four weeks although painful excess callus may form if weight is borne on the foot too early The severe direct force causing multiple metatarsal fractures also injures the soft structures of the foot and often a large hematoma forms. Such a hematoma envelops the nerves vessels and tendons in a hard mass of fibrous tissue and causes chronic thickening and pain in the foot Uncorrected overlapping of the fragments almost invariably causes chronic pain on weight bearing and consequent disability If proper support is neglected during convalescence these injuries are followed by traumatic flat foot with weakness and pain in the metatarsal region

Treatment When there is no displacement and there are no complica

nately in hot and cold water twice daily The whirlpool bath is useful for persistent edema (See Physiotherapy page 81) Do not permit weight bearing until after the eighth week, as early function may cause



Fig 269 Walking Cast for Fractures of the Foot
The rocker plate attached to the cast enables the patient to walk without bending the foot

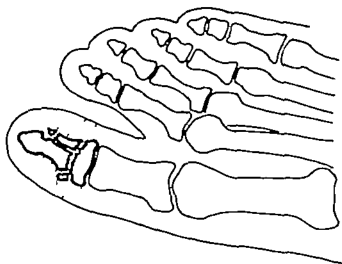


Fig 270 Compound Comminuted Fracture of the Toe
The dotted portion represents the area infected by the crushing injury Debridement and rest in bed are indicated

excess callus formation with subsequent pain The foot should be supported with a metatarsal plate for several months

Fractures of the phalanges. *Etiology* A majority of fractures of the toes are caused by direct force The crushing nature of the injury frequently produces a hematoma under the nail The distal phalanx may



FIG 267 MARCH FRACTURE OR SOLDIER'S FRACTURE
The large mass of callus which forms is characteristic of this condition and is indicated by broken lines

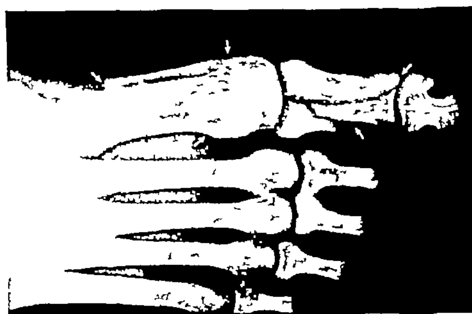


FIG 268 CRUSHING INJURY OF THE GREAT TOE
The fracture involves the metatarsal as well as the proximal phalanx

Follow-up treatment Immobilize metatarsal fractures which are displaced or multiple for eight weeks Then give physiotherapy if there is persistent swelling and instruct the patient to immerse the foot alter

tarsophalangeal joint and there is tenderness to pressure over the plantar surface X ray examination shows a break in continuity of the sesamoid bone the edges of the fracture being rough The appearance of some sesamoid bones having a congenital division with smooth edges, may be mistaken for fracture The pain caused by these fractures usually can be relieved by the application of a felt bunion pad, although operation for removal of the bone is sometimes necessary



Fig 272 Fracture of Sesamoid Bone
In examining the X ray film a bipartate sesamoid should not be mistaken for fracture

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be broken by simply stubbing the toe Many of these fractures are compound and comminuted on account of the direct nature of the injury

Examination These injuries cause severe pain edema and localized thrombosis There is seldom much displacement and it may not be possible to detect crepitus X ray examination should be ordered routinely after all serious injuries of the toes as without this it may be impossible to make a positive diagnosis

Prognosis Simple fractures of the toes do not cause permanent disability although many are never followed by bony union Compound fractures often cause infection but in most instances this is easily controlled

Treatment Fractures of the distal phalanx seldom require immobilization For fractures in the shaft of a phalanx bind two adjacent toes together or fasten a wooden tongue depressor to the toe and forefoot with adhesive plaster If there is a hematoma under the nail it should be

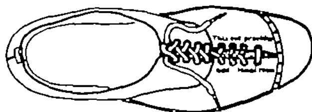


FIG 271 ALTERATION OF A SHOE FOR SWELLING IN THE FOOT
The shoe can be worn over an edematous foot by slitting it from the tongue to the box. Extra eyelets may be provided for the shoe lace

evacuated by drilling or cutting a small hole in the nail For comminuted or multiple fractures of several toes mold a plaster splint to the foot and extend it beyond the toes for protection against further injury In most instances these injuries do not cause disability and the patient can wear a shoe with the box cut out Give physiotherapy and contrast foot baths for residual pain and swelling (See Physiotherapy page 81) When crushing force produces a compound fracture, give tetanus antitoxin and do an early debridement (See Chapter III) Treat infection of the toes with a continuous warm boric acid compress and keep the patient in bed until signs of infection and edema have subsided If osteomyelitis develops it should be treated conservatively amputation or removal of the phalanx being unnecessary

Fractures of the sesamoid bones. The sesamoids lie in the flexor brevis tendon underneath the metatarsophalangeal joint of the great toe and are occasionally broken by jumping on the tip-toes or by the impact of a heavy object

The patient complains of pain on bearing weight upon the first meta

tarsophalangeal joint and there is tenderness to pressure over the plantar surface X-ray examination shows a break in continuity of the sesamoid bone the edges of the fracture being rough The appearance of some sesamoid bones having a congenital division with smooth edges may be mistaken for fracture The pain caused by these fractures usually can be relieved by the application of a felt bunion pad although operation for removal of the bone is sometimes necessary

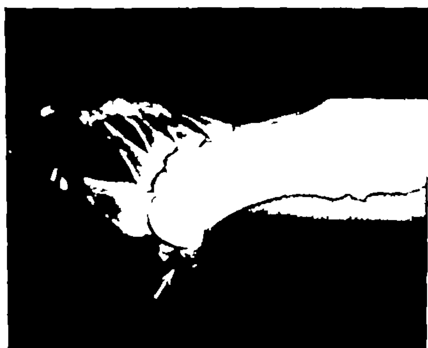


FIG 272 FRACTURE OF SESAMOID BONE
In examining the X-ray film a bipartate sesamoid should not be mistaken for fracture

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PART TWO DISLOCATIONS

CHAPTER XXII

GENERAL CONSIDERATIONS

Definitions. Before considering the individual dislocations it is appropriate to outline their general principles.

A *dislocation* or *luxation* is a complete, persistent displacement of the articular surfaces of a joint.

A *subluxation* is an incomplete dislocation, the articular surfaces being partially displaced.

A *compound dislocation* is a dislocation which communicates with an external wound.

Severe injury sometimes causes *fracture-dislocation*, a combination of dislocation and fracture, which often is compound.

Dislocations which occur repeatedly are called *recurrent* or *habitual dislocations*.

Pathological dislocations are the result of disease and are not treated as traumatic conditions. Congenital dislocations are developmental and have no relation to traumatism.

Etiology of dislocations. Dislocations are caused by indirect force or by direct force. When the force is indirect the leverage displaces the bone through a tear in the joint capsule and stretches the remainder of the soft structures. In some instances muscular action alone can produce a dislocation. When dislocation is caused by direct force it is accompanied by severe contusion of the soft parts with extensive rupture of the ligaments. Instead of the capsular ligaments being ruptured the force may tear them from their bony attachment.

Subluxations are caused by incomplete rupture of the capsular ligaments or may be due to muscular weakness and relaxation of the joint capsule. Some persons are predisposed to multiple and repeated subluxations because their ligaments are unusually elastic, and they can produce a "snapping joint" at will.

Recurrent dislocations occur because the torn capsular ligaments have not healed, the articular surfaces being displaced easily and frequently. In most instances recurrence can be attributed to insufficient immobilization.

Compound dislocations occur in the same manner as compound fractures. Usually they are produced by extreme direct force, the wound being contaminated because the crushing injury carries infection inward. Occasionally compound dislocations are the result of unusually violent leverage, the displaced bone breaking through the skin from within outward.

In some instances this is not necessary for a positive diagnosis while in other instances the signs may not be definite and the condition of the interior of the joint can be learned only by this means. Often an accompanying minor fracture can be detected only by the X ray film. In every case an X ray examination before and after the treatment is a valuable part of the record.

Complications of dislocations. Dislocations are accompanied frequently by avulsion or sprain fractures, a small portion of bone being torn off as the bone is displaced. With the combination of a major fracture and a dislocation there is often severe injury to the soft structures and the tendons may be torn from their bony attachments. The causative force or pressure of the displaced bone may injure the vessels and nerves, or these structures may be damaged by violent attempts at reduction. Myositis ossificans may develop where the periosteum has been stripped from the bone, especially after dislocation at the elbow. Compound dislocations may result in infection, sepsis and ankylosis. Recurrence of dislocation is fairly common, especially at the shoulder.

Prognosis of dislocations. The damage to the capsular ligaments and immobilization after the injury produce scar tissue and contractures which cause restriction of movements. In most instances motions can be restored by exercises within a few weeks after the period of immobilization. Fracture-dislocations often are followed by marked limitation of movements due to the formation of excessive scar tissue, or on account of the projection of a displaced fragment. In these cases the prognosis with operation is decidedly better than with conservative treatment. Compound dislocations are serious, often resulting in severe sepsis and permanent restriction of motions. Amputation may be necessary, or the patient may die from the infection.

Treatment of dislocations. Dislocations should be reduced immediately as delay increases the swelling and the continuous pressure of the displaced bone may cause serious damage to the soft parts. In most instances general anesthesia is necessary for muscular relaxation. For dislocations produced by leverage the displaced bone must be replaced also by leverage returning through the rupture which it produced in the joint capsule. Violent force never should be used, as it may produce a fracture or damage to the vessels and nerves. After reduction, which may occur with a snap, the relation of the bony prominences is restored and the joint movements are free in all directions. In most dislocations caused by severe direct violence the tear in the capsular ligaments is so large that reduction can be accomplished simply by direct pressure combined with traction. Manual traction and continuous traction with weights usually are not as effective as manipulation by leverage, although occasionally these are useful if leverage is unsuccessful. In exceptional cases it is impossible to reduce a dislocation

Examination of dislocations. In taking a history of the accident before the examination it is important to note the nature of violence and to inquire as to whether or not the joint was previously injured or dislocated. There is decided pain although usually not as much as produced by fractures. Numbness from pressure on sensory nerves is not uncommon. The usual signs of dislocation are deformity, swelling, partial or complete loss of function, and rigidity. *With extreme damage to the ligaments there is abnormal mobility.* If the condition has existed for several days the edema and loss of function are less pronounced. On manipulation a rubbing sensation may be detected but the sharp crepitus which is characteristic of fractures is absent except in fracture-dislocations. The presence of nerve injury should be noted.

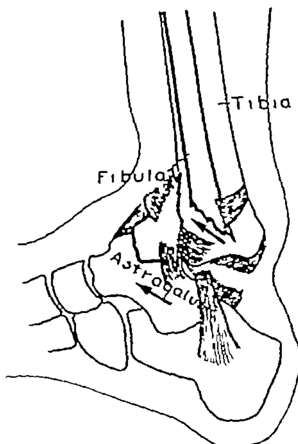


FIG 273 DIAGRAM OF A DISLOCATION
Anterior dislocation at the ankle with an accompanying fracture of the fibula. This drawing illustrates the tearing of ligaments which occurs with a dislocation.

After severe accidents the entire body should be examined, as there may be accompanying fractures, and the possibility of visceral damage should be considered.

X-ray examination should be ordered after every severe joint injury.

similar to that for compound fractures (See Chapter III) It is important to avoid further contamination of the wound from the surrounding skin The wound should be enlarged if necessary Reduction must never be done until after the wound has been thoroughly irrigated with sterilized warm saline solution The capsular ligaments then are sutured and if the operation has been performed soon after the injury it may be considered safe to close the skin If several hours have elapsed since the compound dislocation occurred the wound should be closed loosely and a drain left in it or it may be well to leave it wide open and cover it with vaseline gauze Compound dislocations which occur in war should be left open Prophylactic injection of tetanus antitoxin should be given The joint then should be immobilized plaster of Paris being most satisfactory for this purpose If suppuration occurs the joint should be kept in the most useful position for function anticipating limitation or loss of motion

Follow-up treatment of dislocations. It is important to immobilize joints which have been dislocated for several weeks to permit healing, otherwise there will be permanent weakness of the capsular ligaments and displacement can recur with relatively little force Usually it is difficult to restrain the patient after the period of pain has subsided and he must be cautioned to continue resting the joint In many instances the patient recovers function simply by exercising although physiotherapy may be necessary after severe injuries Operation is necessary for recurrent dislocations

Precautions for dislocations. Although the majority of dislocations produce typical diagnostic signs X rays should be ordered before and after treatment for accuracy and record Anesthesia should be used routinely and extreme force should be avoided Manipulation never should be delayed although if the patient has eaten shortly before the injury it is advisable to wait until the stomach is empty If reduction cannot be accomplished by manipulations either the technic is faulty or open reduction is necessary A dislocation is not reduced unless the normal range of movements is possible after manipulation Complications and injuries in other parts of the body should not be overlooked

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by manipulation operation being necessary in order to retract the interposing ligaments and tendons Open reduction is usually required for severe fracture-dislocations and for old dislocations When there is exten

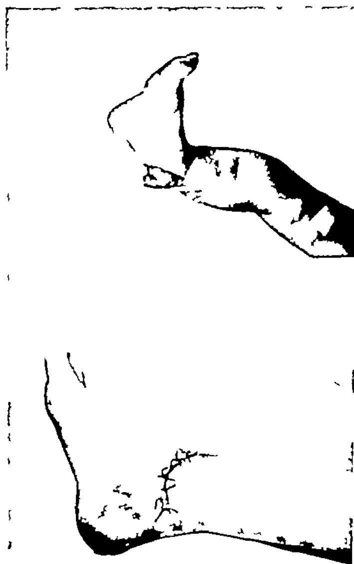


FIG 274 COMPOUND DISLOCATION OF THE ANKLE
Primary healing occurred after a prompt debridement operation Sulfanilamide was placed in the wound and the skin was sutured Such closure of compound fractures and dislocations is permissable in many instances, but not in war surgery

sive rupture of ligaments the dislocation is easily reduced but on account of the extensive tearing the dislocation easily recurs

Compound dislocations require an immediate debridement operation

Treatment General anesthesia is helpful, although usually it is not necessary. Bandage the thumbs for protection and press downward and backward on the lower molar teeth at the same time carrying the chin upward, the condyles are replaced with a snap and normal movement is restored. Instruct the patient to avoid extreme movements of the jaw for one month. If the socket is shallow there may be recurrence of the dislocation.

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CHAPTER XXIII

TEMPOROMANDIBULAR JOINT

Etiology Each temporomandibular joint is composed of the condyle of the mandible and the glenoid fossa of the temporal bone The capsule of this joint is loose permitting rather free movements Dislocations are usually bilateral and forward They are usually caused by muscular

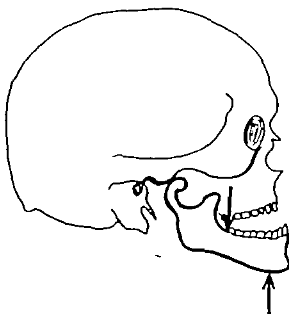


Fig 275 Anterior Dislocation of the Jaw

The stretching or tearing of the capsule permits the condyle of the mandible to leave the glenoid cavity Arrows indicate direction of pressure necessary for reduction

action as in yawning or laughing or occasionally by direct force as a blow The condyles leave the glenoid fossae and are displaced into the zygomatic fossae by the strong pull of the pterygoid muscles

Habitual subluxation of the jaws is due to a congenital shallowness of the glenoids or a faulty occlusion of the upper and lower teeth This condition which is found most often in young women causes a bothersome clicking or snapping on movements of the jaw

Examination With bilateral anterior dislocation the lower jaw projects forward and the upper and lower teeth cannot be brought together The condyles can be palpated lying in a forward position, and the masseter muscles are tense With unilateral dislocation the chin deviates toward the unaffected side, and there is a prominence of the condyle

dislocations. The patient should be completely relaxed under general anesthesia, Pentothal sodium or ether being preferred. If gentle extension followed by hyperextension fails to correct the displacement, the neck should be manipulated by Walton's method as follows. The deformity is increased by rotating the head slowly and tilting it laterally and backward away from the affected side; reduction then is completed by rotating the head toward the affected side. The success of this manipulation depends upon the uninjured articulation on the opposite side of the spine acting as a



Fig. 276. Complete (Bilateral) Dislocation of the Neck

fulcrum, permitting the caught facet to be released and lifted from its displaced position.

After reduction a plaster collar should be applied, extending from the occiput and chin to the upper portion of the chest, with the neck slightly hyperextended. (See Use of plaster of Paris, page 50.)

In one month the plaster collar may be replaced by a removable leather collar or a cervical brace which permits physiotherapy during the remaining two months of immobilization. (See Physiotherapy, page 81.) The injury to ligaments and muscles may cause permanent limitation of motion

CHAPTER XXIV

SPINAL AND SACROILIAC JOINTS

Dislocations of the neck. *Etiology* The spine is composed of a series of vertebrae having interlocking joints on each side which are intimately connected by ligaments There is much more motion in the neck than there is in the remainder of the spine, which fact accounts for the relative frequency of dislocations in this region Dislocations in the neck are caused by violent twists or by falls on the head and may be unilateral or bilateral When unilateral dislocation occurs the articular process of a vertebra rotates and slips over the corresponding articular process of the vertebra below it and remains caught upon it A unilateral displacement accompanied by a fracture of the articular surface may be considered as a fracture-dislocation but when the fracture is more severe than the dislocation the case should be considered as being essentially a fracture Bilateral dislocation seldom comes under observation as it usually causes instant death on account of shearing the spinal cord Gradual and progressive subluxation sometimes accompanies tuberculosis and other destructive arthritis of the cervical spine

Examination Unilateral dislocations produce a characteristic torticollis with the head tilted to one side and the chin rotated away from the side of displacement The muscles on the unaffected side of the neck are kept tense by the displacement while those on the affected side are relaxed The deformity of congenital torticollis and wry neck from myositis is similar to that of dislocation but with these forms of torticollis there is no history of injury With fracture-dislocations the deformity is not completely fixed (See Fractures of the Vertebrae)

With all injuries of the neck careful X ray examination is of great help The surgeon must depend upon the roentgenologist for the interpretation of the films otherwise there may be an error in diagnosis

Treatment Incomplete dislocations usually can be reduced by placing the patient in bed and applying two or three pounds of traction to the head with a split muslin bandage or Glisson sling the head of the bed being elevated for counter traction A sedative should be prescribed for relaxation The traction is removed the following day for inspection of the neck reduction is evident by relief from pain and rigidity and the absence of deformity with corroborative X ray examination If the dislocation fails to respond to traction for 24 hours manipulation is indicated

Experience is necessary for the safe and successful manipulation of these



FIG 275 DISLOCATION OF NECK
The typical appearance is due to unilateral dislocation in the cervical spine

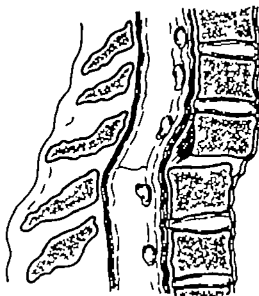


FIG 270 DIAGRAM OF COMPLETE DISLOCATION
Illustrating pressure on the cord by the displacement (after Stimson)

in the neck, and peripheral neuritis from the stretching is common A useful support for minor injuries can be made by wrapping a rectangular piece of one-half inch felt around the neck and making it rigid by applying a plaster of Paris bandage over it

Precautions Never treat injuries of the spine without a preliminary X ray examination and study the films with the roentgenologist Reduc



FIG 277 UNILATERAL DISLOCATION OF THE NECK

Note the displacement and rotation of the articular facets between the fifth and sixth cervical vertebrae and the change in the alinement of the spinous processes This dislocation was reduced by manipulation under anesthesia traction in bed having been unsuccessful

tion should be performed only by an experienced operator and only under complete anesthesia The dislocation is reduced by leverage never by manual traction The test of reduction is complete disappearance of the torticollis The neck always should be supported with plaster after reduction for without immobilization the stretched condition of the ligaments predisposes to recurrence Fracture-dislocations should not be manipulated

the displacement X ray examination shows rotation and tilting of the vertebra with displacement of the spinous process from the midline

The reduction of a unilateral subluxation in the lower back requires a considerable amount of skill It is manipulated similarly to unilateral dislocation in the cervical region, rotating the pelvis on the spine while the



FIG 281 DISLOCATION IN THE LUMBAR SPINE
Manipulation of such a bilateral dislocation is dangerous The most satisfactory form of treatment is gentle open reduction

unaffected articulation acts as a fulcrum The patient lies in the supine position with his hips and knees fully flexed and supported at the end of the table by the operator As the lower spine is suddenly hyperflexed the hip on the affected side should be rotated upward and away from the affected side Reduction usually occurs with a snap and pain is relieved

In the lower back another congenital imperfection is *spondylolisthesis* or forward dislocation of one vertebra upon the vertebra below it Usually

Dislocations of the lower back Unilateral dislocation or subluxation also may occur in the lumbar region especially between the fifth lumbar vertebra and the sacrum This condition is unusual in normal spines occurring typically in instances of *tropism* In tropism there is an asymmetry the plane of the facets at one of the articulations of the lumbosacral joint being oblique or nearly horizontal instead of perpendicular consequently an unusual twist of the lower back combined with flexion or

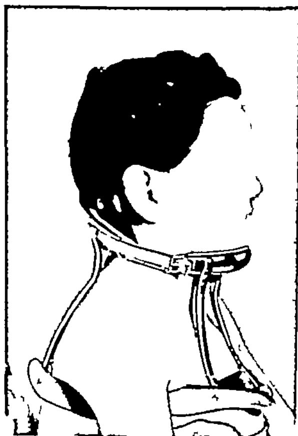


Fig 280 Cervical Brace
This is satisfactory after minor injuries as unilateral dislocations but severe injuries require plaster of Paris or a long brace

extension may cause a dislocation on the side of the spine the articulation on the opposite side acting as a fulcrum

Unilateral dislocation or subluxation at the lumbosacral joint causes pain and disability The patient stands and walks with a list to the affected side and there is an apparent shortening of the lower extremity on account of muscle tension Pain may be present only on movements of the lower back or there may be posterior nerve root pain on account of

the displacement occurs between the fifth lumbar vertebra and the sacrum, this is present before injury, but is aggravated by the injury. This condition is characterized by pronounced aching and weakness in the lower back, there is a pronounced lordosis, and the patient is unable to bend forward naturally. The physician should examine every case of backache carefully as many are mistreated for sprains or lumbago on account of negative X ray reports. The acute symptoms of spondylolisthesis may be relieved by rest in bed and support with a plaster of Paris jacket or a brace although severe cases usually require operative treatment for permanent relief.

Dislocations of the sacroiliac joint. Dislocation at this joint is unusual, on account of the great strength of its ligaments and the peculiar shape of

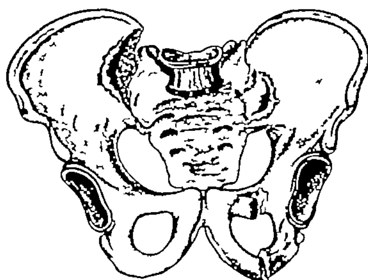


FIG 284 DISLOCATION OF RIGHT SACROILIAC JOINT
This extreme displacement is uncommon without such accompanying damage as fracture of the pubic rami and sprain of the left sacroiliac joint which also are shown (redrawn from Sir Astley Cooper)

the synchondrosis however severe force occasionally produces complete separation and displacement. Dislocation of the sacroiliac joint sometimes accompanies fracture of the pelvis produced by extreme anteroposterior compression injuries. Often the diagnosis of so-called sacroiliac dislocation is an illusion as the apparent shortening of the limb which suggests this diagnosis is caused merely by a tilting of the pelvis due to pain and lumbar muscle spasm from injury or inflammation. Nevertheless rotation and subluxation probably occur more often than generally are recognized although X ray corroboration of such a diagnosis is doubtful. Separation or spreading of this joint occurs during pregnancy but dislocation does not occur from this cause.

When an actual dislocation exists the displacement of the ilium is usually



Fig 282 Spondylolisthesis
Subluxation of the spine usually due to a congenital defect (Courtesy of Dr W E. Lee)



Fig 283 Manipulation for Dislocation at Lumbo-Sacral Joint
Flexion combined with rotation away from the affected side

one of the pubic bones is decidedly higher than the other The shift is even more noticeable in comparison films exposed while the patient lies and stands

For the reduction of a subluxation in which the ilium is anterior the patient should lie in the supine position The operator flexes the hip and knee and adducts the knee to the mid line of the body Then, with his interlocked hands he makes sudden downward pressure on the flexed knee



FIG 287 DISLOCATION OF SACROILIAC JOINT
There also are fractures of the pelvic bones This patient had severe ileus

If the ilium is posterior the operator exerts sudden upward traction upon the flexed knee with his flexed elbow as he simultaneously lifts the hip upward with his other hand

For complete or recurrent dislocation of the sacroiliac joint the only satisfactory treatment is an arthrodesis or bone graft operation which eliminates movement

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palpable, and there is a decided excursion of this bone when the back is flexed and extended The sacral plexus may be injured by the displace-

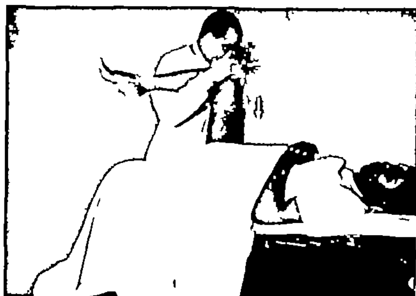


FIG 285 MANIPULATION FOR ANTERIOR DISPLACEMENT OF THE ILIUM
Sudden backward pressure is made upon the flexed knee

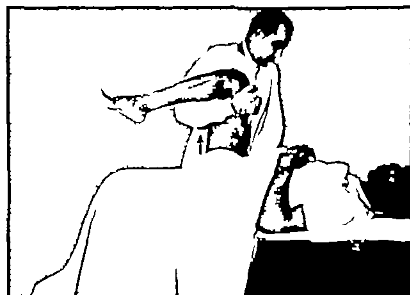


FIG 286 MANIPULATION FOR POSTERIOR DISPLACEMENT OF THE ILIUM
The operator makes upward traction on the flexed knee assisted by traction on the hip

ment In X ray examination of the pelvis for cases of suspected sacroiliac dislocation probably the most reliable sign is the appearance of the symphysis pubis when there is a marked unilateral displacement of the ilium

CHAPTER XXV

JOINTS OF CLAVICLE

Dislocations at the sternoclavicular joint. *Etiology* The sternoclavicular joint is composed of the inner end of the clavicle and the sternum, which are bound together by the sternoclavicular ligament The joint is reenforced by the costoclavicular ligament which holds the proximal end of the clavicle to the first rib Dislocation at this joint which is uncommon, is more often anterior than posterior Anterior displacement occurs when the shoulder is violently depressed backward and downward by a blow from behind or when the shoulder is extremely hyperextended Such force ruptures the sternoclavicular ligament although the costoclavicular ligament remains intact With posterior dislocation the sternal end of the clavicle is displaced behind the manubrium

Examination Depending upon whether the clavicle is displaced anteriorly or posteriorly there is either a corresponding prominence or a depression at its sternal end with increased deformity and insecurity on movements of the shoulder X ray films may show an avulsion fracture accompanying the dislocation When the dislocation is posterior it may cause pressure on the structures at the base of the neck

Treatment It usually is not necessary to give anesthesia To reduce anterior displacement press the shoulders backward and at the same time manipulate the inner end of the clavicle into place Apply criss-cross adhesive strapping and a sling to immobilize the shoulder for six weeks

For reducing a posterior dislocation the patient should lie on his back with a narrow sandbag placed between the scapulae Make traction on the arm as it is held abducted at a right angle thus permitting the clavicle to slip forward into its normal position Then use adhesive strapping and a sling for six weeks

In some instances it is impossible to hold the clavicle in place after manipulation on account of extensive damage to the ligaments and open reduction and suture is necessary Recurrent dislocation can be cured only by operative reconstruction of the sternoclavicular ligament

Dislocations at the acromioclavicular joint. *Etiology* The acromioclavicular joint is formed by the acromion process of the scapula and the outer end of the clavicle these parts being bound together by the acromioclavicular ligaments and reenforced by the coracoclavicular ligament The tight construction of the joint permits very little motion consequently when extreme force is applied the ligaments are torn severely Sprain

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CHAPTER XXX

JOINTS OF CLAVICLE

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with incomplete dislocation at this joint is common although complete dislocation is uncommon The commonest cause of this condition is a

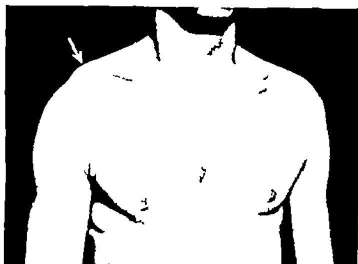


FIG 268 DISLOCATION AT RIGHT ACROMIOCLAVICULAR JOINT
Note the prominence of the distal end of the clavicle



FIG 269 DISLOCATION AT ACROMIOCLAVICULAR JOINT
Note the upward displacement of the clavicle and the lateral spreading of the joint To show the entire extent of displacement the X ray examination should be made while the patient stands

heavy fall or severe blow upon the side of the shoulder sustained during athletics as football and horseback riding

Examination The affected shoulder should be compared with the normal shoulder The outer end of the clavicle is free and projects upward, and as this joint is subcutaneous the displacement is visible and easily palpated The extent of abnormal movements and displacement depends upon the severity of injury Movements of the shoulder are painful and restricted and the prominent outer end of the clavicle can be depressed by the examining finger as upward pressure is made on the elbow X ray examination is useful for differential diagnosis and may show an accompanying avulsion fracture In order to show the amount of separation the

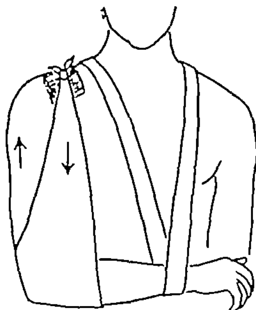


FIG 200 DRESSING FOR ACROMIOCLAVICULAR SPRAINS AND DISLOCATIONS
Sir Robert Jones method This dressing elevates the shoulder and depresses the clavicle Note the pad of felt placed over the area of pressure For extra security an additional loop of bandage may be fastened to the knot and passed under the opposite arm The method is not satisfactory for complete dislocations

film should be exposed while the patient stands and a downward pull is exerted on the arm

Treatment Treat incomplete dislocations with or without fracture at the acromioclavicular joint by the Jones dressing Press downward on the clavicle and elevate the shoulder by applying a tight triangular sling under the elbow with the knot tied over the outer end of the clavicle Support the wrist with a sling and continue the immobilization for four weeks Partial dislocations are followed by moderate weakness of the shoulder, although there is no disability except for heavy work

With complete dislocations the ligaments are so severely torn that they never unite with simple immobilization and there is permanent partial disability on account of pain and weakness The only effective treatment is operative repair which should be done without delay

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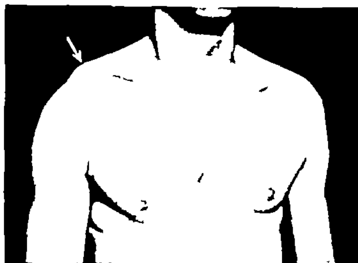


FIG 288 DISLOCATION AT RIGHT ACROMIOCLAVICULAR JOINT
Note the prominence of the distal end of the clavicle



FIG 289 DISLOCATION AT ACROMIOCLAVICULAR JOINT
Note the upward displacement of the clavicle and the lateral spreading of the joint To show the entire extent of displacement the X ray examination should be made while the patient stands

heavy fall or severe blow upon the side of the shoulder sustained during athletics as football and horseback riding

CHAPTER XXVI

SHOULDER JOINT

Etiology. The shoulder is a relatively weak joint, the strength of which depends upon its thin capsular ligaments and its muscles. There is no security from its bony structures, as the glenoid is only slightly concave and is not a socket. Dislocations at the shoulder occur frequently on account of such structural weakness, its exposed position, and the great range of motions to which it is subjected. About 50 per cent of all dislocations involve the shoulder, most of them occurring in male adults who engage in strenuous occupations and recreation. The two main types of dislocations are anterior or subcoracoid and posterior or subspinous; the majority are of the anterior type. Although usually caused by leverage, occasionally dislocations are the result of violent direct force and even may be due to muscular action, as in throwing a ball.

Anterior dislocations. Most dislocations are anterior and are produced by indirect violence. When force is applied behind the shoulder with the arm raised and abducted, the head of the humerus is thrust through the capsular ligaments so that it lies below the coracoid process. Nicola has shown that in most cases the capsule is torn off the neck of the humerus or less frequently it is pulled away from the margin of the glenoid. The head is held fixed in this displaced position by the tension of the subscapularis muscle.

Examination. With anterior dislocation the deformity is characteristic. The superior outline of the affected shoulder is lower, the lateral outline is flattened, and there is an abnormal prominence of the acromion with a hollow below it. This hollow space may not be visible, although it can be palpated readily. There is complete loss of shoulder function with the arm held rigidly abducted at a short distance from the side of the body. In a typical case the patient cannot place the hand on the opposite shoulder and complete adduction is impossible.

Dislocation of a shoulder should be differentiated from epiphyseal separation and fracture in the neck of the humerus. An X-ray examination always should be made in a standard position, with the arm at the side of the chest and the thumb pointing forward. Normally at least one-third of the articular surface of the humerus is parallel to and in proper relationship to the glenoid of the scapula.

Complications. More than one-half of the dislocations at the shoulder are said to be complicated by injury to the circumflex nerve with conse-

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of the humerus sometimes is combined with dislocation of the head (fracture-dislocation). There may be an associated fracture of the coracoid or acromion process. Rupture at the insertion of the supraspinatus tendon on the greater tuberosity is another disabling complication and displacement of the tendon of the long head of the biceps has been found.

Prognosis. In a majority of instances dislocation at the shoulder is followed by complete recovery. Contractures of the capsule and adhesions cause limitation of motion. Recurrence is caused by failure to immobilize



Fig. 293. Reduction of Anterior Dislocation at the Shoulder

The operator makes lateral traction combined with countertraction. In addition pressure upward and backward on the upper portion of the humerus may be necessary.

the shoulder after the first injury or by repeated violence. The various complications which may occur usually produce a considerable disability.

Treatment. Although an X-ray examination should be made routinely before the dislocation is treated, reduction should not be delayed for several hours if it is necessary to wait that long for this examination. Unless the displacement is corrected promptly the pressure of the dislocated head may cause serious nerve damage. If treated within one or two hours after injury anesthesia may not be necessary. If several hours have elapsed a general anesthetic usually is necessary for muscular relaxation, although

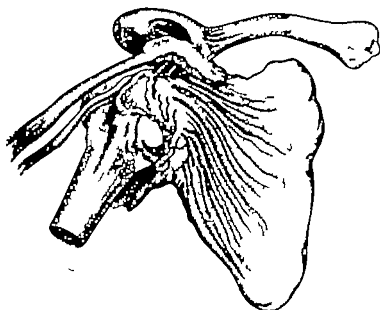


FIG 201 ANTERIOR DISLOCATION AT THE SHOULDER JOINT SHOWING CAPSULE PEELED OFF HUMERUS (REDRAWN FROM SIR ASTLEY COOPER)



FIG 202 ANTERIOR (SUBCORACOID) DISLOCATION OF THE SHOULDER

quent weakness of the deltoid muscle Dislocation is occasionally accompanied by fracture of the greater tuberosity and in rare instances the capsule tears off the inferior margin of the glenoid Fracture in the neck

is recommended as an alternative if the abduction pressure method fails. To follow this method flex the elbow and hold the arm to the side of the body. Then slowly but completely externally rotate the arm and next lift the elbow forward and across the chest, finally rotate the arm inward and place the hand on the opposite shoulder. The explanation of this mechanism is as follows: When the humerus is externally rotated the contraction of the pectoralis and subscapularis muscles is overcome and the gap in the capsule is widened; the head now rests on the edge of the glenoid, and adduction and internal rotation guide it through the tear in the capsule and rotate it back over the glenoid fossa. With Zierold's method the patient lies on his back, and the operator stands on the side of the affected

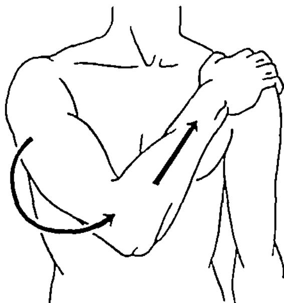


Fig. 205. Test for Reduction of Dislocation at Shoulder
No dislocation can exist if it is possible to place the hand on the opposite shoulder

shoulder and facing toward the foot of the table. The patient's wrist is grasped with his elbow extended, the arm being abducted to 90 degrees. The operator's elbow then is placed in the patient's axilla with his hand in the bend of the elbow. By using his hand as a fulcrum the operator now flexes the elbow to make traction on the dislocated humerus. The maneuver is completed by further flexing the elbow as the humerus is adducted.

Whichever form of manipulation is used should be performed slowly and deliberately, without jerking or attempts to elicit a snap. To test for reduction place the hand over the opposite shoulder with the elbow in contact with the chest; if this cannot be done the humerus still is dislocated.

Follow-up treatment. In uncomplicated cases immobilize the shoulder with a sling and fasten the arm to the chest with a broad strip of adhesive

manipulation may be tried once without it Anterior dislocation usually can be reduced by simply making steady traction on the arm while it is



FIG 294. REDUCTION OF ANTERIOR DISLOCATION BY THE KOCHER METHOD

First the elbow is flexed to a right angle Then with the elbow touching the chest the arm is rotated outward until the forearm points directly away from the side of the body

Next the arm and elbow are kept in the same position and the elbow is raised across the chest to the mid line of the body

Finally the arm is rotated inward and the hand is placed on the opposite shoulder thus completing reduction

abducted at a right angle combined with direct pressure upon the head of the humerus with the fist

The Kocher manipulation is performed routinely by many surgeons and

is recommended as an alternative if the abduction pressure method fails. To follow this method, flex the elbow and hold the arm to the side of the body. Then slowly but completely externally rotate the arm and next lift the elbow forward and across the chest; finally, rotate the arm inward and place the hand on the opposite shoulder. The explanation of this mechanism is as follows: When the humerus is externally rotated the contraction of the pectoralis and subscapularis muscles is overcome and the gap in the capsule is widened; the head now rests on the edge of the glenoid, and adduction and internal rotation guide it through the tear in the capsule and rotate it back over the glenoid fossa. With Zuroldi's method the patient lies on his back and the operator stands on the side of the affected

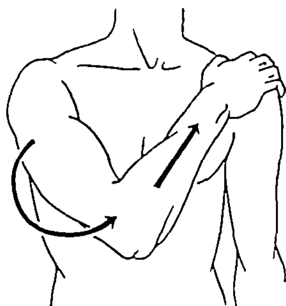


FIG 295 TEST FOR REDUCTION OF DISLOCATION AT SHOULDER
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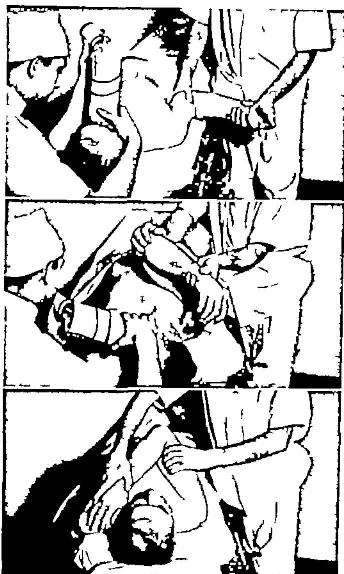


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Finally the arm is rotated inward and the hand is placed on the opposite shoulder thus completing reduction.

abducted at a right angle combined with direct pressure upon the head of the humerus with the fist

The Kocher manipulation is performed routinely by many surgeons and

position in a brace or plaster of Paris spica to relax the muscles which cause the displacement. If there is marked displacement of the tuberosity an operation for internal fixation is necessary. After six weeks give physiotherapy and exercises. (See Physiotherapy and motions, page 81.)

When complicated by rupture of the supraspinatus tendon, which is indicated by localized tenderness and a depression over the tuberosity with inability to abduct the arm without help, operation for the immediate suture of the tendon is indicated.

When there is severe injury to the circumflex nerve resulting in deltoid paralysis, denoted by early atrophy and a lack of voluntary abduction, use an abduction brace or apply a plaster of Paris spica to maintain the salute position for six weeks or longer, depending upon the recovery of voluntary abduction.

For treatment of fracture-dislocations at the shoulder see Fractures in the neck of the humerus.

Posterior dislocations. This uncommon form of shoulder dislocation is caused by a fall with the arm adducted, or by a blow on the flexed elbow with the shoulder adducted and internally rotated. Such force drives the head of the humerus through the posterior part of the capsule to a position under the spine of the scapula.

The anterior contour of the shoulder is flattened, with a corresponding palpable depression. Movements of the joint are restricted, but the hand may be placed over the opposite shoulder. It may be difficult to recognize this condition by X-ray examination.

To reduce, make steady traction on the arm while forward pressure is made on the head of the humerus. Zierold's method also is useful. (See Anterior dislocation of the shoulder.) Following reduction, the arm must be kept internally rotated for six weeks to permit healing of the torn capsular ligaments. This is accomplished by binding the patient's hand to his back, or by applying a plaster of Paris dressing for firm fixation.

Precautions. Order routine X-ray examination of all severe injuries of the shoulder, even when the diagnosis appears certain, as it is not uncommon to find a fracture associated with the dislocation. Examine for evidence of injury to the axillary vessels and nerves. Do not manipulate the shoulder violently, as force may produce a fracture of the greater tuberosity or may injure the axillary structures. Immobilize the shoulder, as failure to do so invites recurrence.

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plaster to prevent abduction and rotations but leave the wrist and hand free for function Keep these cases under close observation throughout the course of treatment watching for possible complications Give heat and massage after the first week to reduce the edema Voluntary movements should be encouraged after the fourth week although abduction *should not be permitted until after the sixth week* (See Physiotherapy and motions page 81)

Repeated dislocation will occur if the shoulder has not been immobilized long enough to permit healing of the tear in the capsule being produced by ordinary movements as raising the arm or throwing a ball In athletes



FIG 206 ANTERIOR DISLOCATION WITH AVULSION FRACTURE

The arm should be abducted to a right angle when the X ray films show the fragment of the tuberosity replaced after reduction of the dislocation If the fragment remains displaced after reduction of the dislocation operation for internal fixation is necessary

the use of an elastic shoulder cap with a check strap for a few months gives protection by limiting abduction Recurrent dislocations are disabling and can be cured only by operation Irreducible dislocation of the shoulder usually is caused by displacement of the tendon of the long head of the *biceps from its groove in the humerus and for this open* reduction is necessary

When dislocation is complicated by fracture of the greater tuberosity the fragment may be loose or considerably displaced If not displaced treat as a dislocation without fracture if the tuberosity has been torn from the head and is slightly displaced immobilize the shoulder in the abducted

position in a brace or plaster of Paris spica to relax the muscles which cause the displacement. If there is marked displacement of the tuberosity an operation for internal fixation is necessary. After six weeks give physiotherapy and exercises. (See Physiotherapy and motion, page 81.)

When complicated by rupture of the supraspinatus tendon, which is indicated by localized tenderness and a depression over the tuberosity with inability to abduct the arm without help, operation for the immediate suture of the tendon is indicated.

When there is severe injury to the circumflex nerve resulting in deltoid paralysis denoted by early atrophy and a lack of voluntary abduction, use an abduction brace or apply a plaster of Paris spica to maintain the "salute" position for six weeks or longer, depending upon the recovery of voluntary abduction.

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Precautions. Order routine X-ray examination of all severe injuries of the shoulder, even when the diagnosis appears certain, as it is not uncommon to find a fracture associated with the dislocation. Examine for evidence of injury to the axillary vessels and nerves. Do not manipulate the shoulder violently, as force may produce a fracture of the greater tuberosity or may injure the axillary structures. Immobilize the shoulder, as failure to do so invites recurrence.

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CHAPTER XXVII

ELBOW JOINT

Dislocations of the ulna *Etiology* Dislocation of the ulna occurs almost entirely in children and of all the dislocations is the next in frequency to dislocation at the shoulder This condition is less common in adults as after maturity the bony prominences are completely developed and the capsular ligaments are stronger The displacement usually is posterior although occasionally it is anterior or lateral In a typical case the child falls on the outstretched hand thus hyperextending the elbow, the capsular ligaments are torn by this sudden force and the forearm bones are displaced posteriorly with the coronoid process of the ulna lying behind the trochlear surface of the humerus In adults the dislocation of the ulna often is accompanied by a fracture of the coronoid process

Examination The elbow is swollen and held in an attitude midway between flexion and extension The olecranon process is abnormally prominent posteriorly and there is a corresponding concavity on the anterior surface of the joint Acute flexion of the elbow is impossible as the triceps is kept taut by the displacement of the forearm bones X ray examination should be ordered before and after treatment for record and to show possible fracture complications Posterior dislocation at the elbow should be differentiated from supracondylar fracture, and from separation of the lower epiphysis of the humerus

Prognosis In a majority of cases limitation of motion is only temporary, and the period of disability averages six weeks Myositis ossificans or ossification of the hematoma which forms in the front of the elbow is especially liable to develop after repeated attempts to gain motion by forcible manipulations In many instances this causes permanent limitation of motion

Treatment Give general anesthesia for complete relaxation To reduce posterior dislocation supinate the forearm to relax the tension of the biceps, then hyperextend the elbow in order to disengage the coronoid process by leverage and make traction downward and forward on the forearm as forward pressure is made on the olecranon thus causing the forearm bones to snap into place If the dislocation has been reduced the joint can be flexed completely Immobilize the elbow at a right angle with a sling for four weeks and then prescribe active movements by swimming pulling weights and carpentry (See Physiotherapy and motions page 81) If there is marked limitation of motion re-examination by X ray may show

myositis ossificans if this is found it is important to avoid manipulation, as the resulting traumatism causes even more bone production with further restriction of movements Operation for removal of this bony mass is followed by fairly good functional results although it must not be done

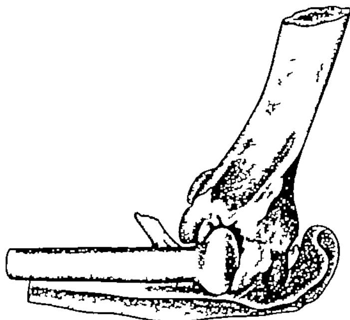


FIG 207 POSTERIOR DISLOCATION AT THE ELBOW JOINT
There is displacement of both the ulna and radius Note rupture of the capsular ligaments of the elbow and rupture of the orbicular ligament (redrawn from Sir Astley Cooper)

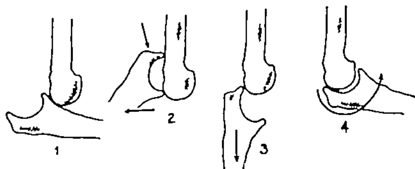


FIG 208 REDUCTION OF POSTERIOR DISLOCATION AT THE ELBOW

until one year after the injury Another occasional complication is displacement of the epiphysis of the internal epicondyle with injury to the ulnar nerve which may require open reduction and fixation In adults fractures of the head or neck of the radius combined with posterior dislocation of the ulna usually require operation Also in adults there may

be an associated fracture of the coronoid process which cannot be reduced when the dislocation is manipulated, and in such instances removal of the

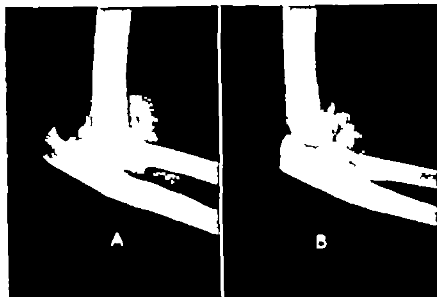


Fig 299 Myositis Ossificans

This is not an infrequent sequel of dislocations at the elbow A before reduction Note the numerous portions of bone torn loose with the muscles B there is a large mass of bone formation around the joint several weeks later

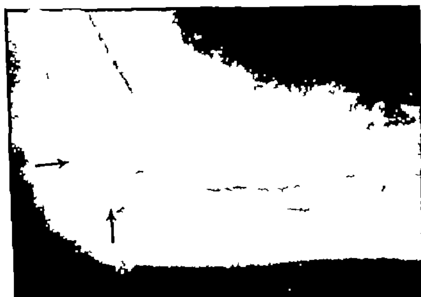


Fig 300 Posterior Dislocation at Elbow with Fracture

The fragment acts as a block to reduction and open reduction may be necessary

fragment is necessary Unreduced dislocations require operative treatment (For treatment of compound dislocations see Chapter III)

Precautions Always use anesthesia Do not neglect to immobilize the elbow for the required period of time Do not give heat massage or passive movements for dislocations of the elbow as these may cause the formation of excess bone If the joint movement is restricted for longer than a few weeks following the immobilization myositis ossificans should be suspected

Dislocations of the radius. Subluxation of the upper portion of the radius is an occasional injury of childhood which is caused by a fall on the



FIG 301 MONTEGGIA FRACTURE DISLOCATION OF THE HEAD OF THE RADIUS ACCOMPANIED BY FRACTURE IN THE PROXIMAL PORTION OF THE ULNA

It is difficult to reduce either the fracture or the dislocation by manipulation and operation usually is necessary

outstretched hand or by forcible hyperpronation of the forearm this indirect force levers the head out through a tear in the orbicular ligament The displacement produces a palpable depression and rotary movements of the forearm are limited To replace the head of the radius apply traction and supinate the forearm pressing back the radial head through the torn orbicular ligament Immobilize the elbow in a hyperflexion bandage with the forearm supinated for four weeks If the radius cannot be reduced by manipulation on account of interposition of the edges of the capsule it must be replaced by operation

In adults severe violence may produce dislocation of the head of the radius accompanied by a fracture in the upper third of the ulna (Monteggia fracture). There is posterior angulation of the fracture and a corresponding anterior displacement of the radial head which may injure the radial nerve. The severity of the traumatism causes such extreme swelling that accurate diagnosis is made only by X-ray examination. Operative treatment is necessary in a majority of instances and immobilization must be continued until the fracture has united.

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CHAPTER XXVIII

WRIST AND HAND

Dislocations of the wrist. *Etiology* When dislocated the carpal bones usually are displaced anteriorly the cause being a fall on the hyperextended wrist or a severe blow Occasionally an injury which forces the wrist into extreme flexion dislocates a carpal bone posteriorly The semilunar (lunate) bone is more often involved than any of the other carpal bones Statistics show that in one-half of the cases of semilunar dislocation there is an accompanying fracture of the scaphoid (navicular) bone one fragment of the scaphoid is dislocated with the semilunar bone Occasionally dislocation of the semilunar bone is accompanied by fracture through the styloid process of the radius

Examination When this injury is caused by indirect violence it may be mistaken for a sprain With anterior dislocation there is swelling and thickening of the wrist which is held in a straight position The semilunar bone is palpated as a hard unyielding prominence under the flexor tendons and an open space normally occupied by the bone can be felt on the dorsal surface of the wrist Flexion extension and lateral movements of the wrist are decidedly restricted The pressure of the displaced bone upon the flexor tendons causes limitation of finger motion and there may be symptoms of pressure on the median nerve In old unreduced cases there is little or no pain although the patient complains of weakness in the wrist and in the grasping power of the hand X ray examination should be ordered routinely after every severe injury to the wrist as otherwise it is impossible to make an accurate diagnosis Both anteroposterior and lateral films are necessary and corresponding views of the unaffected wrist are valuable for comparison Even with X ray examination this dislocation sometimes is overlooked and the presence of an accompanying fracture of the scaphoid bone may not be noticed.

Prognosis Manipulation usually is successful in recent cases Unless the normal position of the bone is restored there will be aching with weakness and limitation of motions especially flexion of the wrist and fingers

Treatment In a majority of cases the dislocation can be reduced by manipulation provided this is performed within the first few days With the patient under general anesthesia apply steady traction while pressing firmly with the thumbs upon the displaced bone holding the wrist hyperextended in order to open the space normally occupied by the semilunar At the same time make pressure on the dorsum of the hand over the head

of the os magnum to increase the space between this bone and the radius If this form of manipulation fails make steady traction on the hand with



Fig 302 Dislocation of Semilunar (Lunate) Bone
The bone is rotated and displaced toward the palm

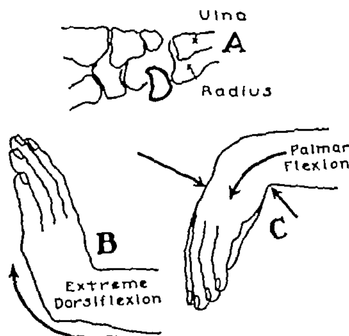


Fig 303 Reduction of Semilunar Dislocation
A lateral view of the wrist showing anterior displacement and rotation of the semilunar bone B the gap in the wrist joint is opened by hyperextension C replacement is usually accomplished by direct pressure followed by flexion of the wrist

the wrist straight for ten minutes this prolonged pull may reduce the dislocation when other methods are ineffective Violent attempts at reduc

CHAPTER XXVIII

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examination immediately after application of the plaster to check the position of the fracture and reduction of the dislocation (For treatment of compound dislocations see Chapter III)

If the dislocation has been unrecognized for several days or longer it will be impossible to reduce it by manipulation because the space normally occupied by the semilunar soon becomes filled with scar tissue Under this circumstance and also when manipulation fails immediate operative replacement of the bone is indicated Removal of the semilunar bone is not as satisfactory as replacement for it leaves a permanently weakened wrist and hand Multiple fracture-dislocations of the wrist caused by extreme violence are disabling on account of chronic pain and limited motion and



FIG 306 DISLOCATION OF THE THUMB
The proximal phalanx is displaced dorsally on the metacarpal bone

the best result is obtained by open reduction and grafting to stiffen the wrist in a useful attitude

Dislocations of the ulna at the wrist joint. This condition occurs most often with severe fractures of the lower forearm and is characterized by dorsal subluxation of the head of the ulna on account of rupture of the radio-ulnar ligament It produces aching and weakness and can be relieved only by operation

Dislocations at the carpometacarpal joints. Extreme force may cause dislocation at one or all of these joints In most instances the carpometacarpal joint at the base of the thumb is involved the metacarpal bone being displaced posteriorly There usually is an associated fracture of the base of the metacarpal bone (Bennett s fracture) Reduce a simple dislocation by traction upon the abducted thumb combined with direct pressure Immobilize the thumb in abduction with a small plaster spica for six weeks

tion damage the bone causing aseptic necrosis and traumatic arthritis Check the reduction by an immediate X ray examination as re manipulation may be necessary Immobilize the wrist in flexion on a plaster splint



FIG 304 DISLOCATION OF THE CARPAL SCAPHOID (NAVICULAR) BONE



FIG 305 FRACTURE DISLOCATION AT THE WRIST

or with a circular plaster of Paris dressing for four weeks (See Use of plaster of Paris page 59) If the scaphoid is fractured immobilize the wrist with an unpadded circular plaster cast for at least four months, on account of the delay in union which is common in this bone Order X ray

slips back into its place After reduction the joint should be immobilized in slight flexion for four weeks In many instances the extensive laceration of the capsular ligaments leaves a permanently thickened and tender joint with limitation of motions and for this prolonged physiotherapy is necessary

Dislocations at the interphalangeal joints. Simple dislocation between the phalanges occurs in the same manner as dislocation at the metacarpophalangeal joints, and produces a similar deformity The more distal phalanx is displaced dorsally on the other phalanx Frequently there is an accompanying minor fracture extending into the joint, which can be diagnosed only by X ray examination Dislocation at an interphalangeal joint is similar to dislocation at a metacarpophalangeal joint being reduced by hyperextension and then flexion Reduction is proved by the ability to passively flex and extend the joint

Immobilize the joint in slight flexion for three weeks and then apply heat and encourage voluntary motion Later use a Thilo glove or elastic traction if there is persistent limitation of flexion

Fracture-dislocation at an interphalangeal joint causes prolonged disability and in many instances is followed by permanent enlargement and stiffness on account of injury to the soft structures the joint cartilage and ligaments or because of incomplete reduction In these cases reduction can be accomplished only by the early use of traction on the end of the finger with Kirschner wire and a banjo splint Regardless of treatment a majority of fracture-dislocations are followed by permanent limitation of motion and the best end result is obtained by prolonged physiotherapy

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and then give heat and massage but avoid passive motions With extensive tearing of the ligaments there is a decided tendency to chronic subluxation with aching and weakness in the grasping power of the hand for this the only satisfactory treatment is operation For treatment of Bennett's fracture see Fractures of the metacarpal bones

Dislocations at the metacarpophalangeal joints. *Etiology* This injury occurs most frequently in the thumb The displacement is produced by forcible hyperextension which levers the head of the metacarpal bone



FIG 307 REDUCTION OF DISLOCATION OF THE THUMB
The operator hyperextends the joint for leverage as he applies local pressure

through the anterior portion of the capsule. Subluxation produced at will is seen in persons whose capsular ligaments are unusually elastic or relaxed

Examination There is a typical deformity with the joint held partly flexed and immovable On palpation the phalanx is found displaced on the dorsum of the metacarpal bone.

Treatment Reduce the dislocation by leverage, as traction cannot be effective Give anesthesia and hyperextend the joint in order to lever the base of the phalanx over the head of the metacarpal bone and then flex the thumb Sometimes it is impossible to reduce the dislocation by manipulation because the head of the metacarpal bone is buttonholed between the flexor tendons Under such circumstances operation is necessary so that the tendons can be retracted and thus the head of the metacarpal bone

If this method fails the Stimson method should be used The patient is placed face downward with the hips hanging entirely free over the end of the operating table While the unaffected limb is supported by an

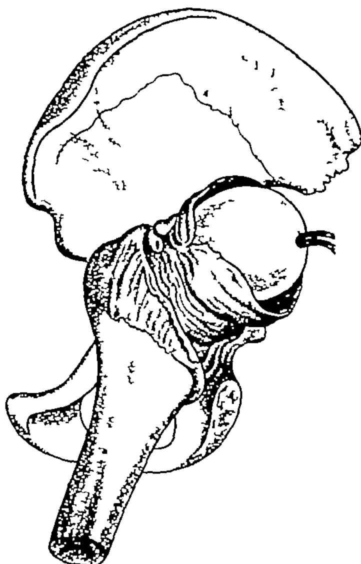


FIG 308 POSTERIOR DISLOCATION OF THE HIP
Note the complete rupture of the capsule and of the ligamentum teres (redrawn from Sir Astley Cooper)

assistant the surgeon grasps the flexed knee and rocks or rotates the thigh while the weight of the limb exerts its own traction A heavy sand bag may be placed on the flexed knee for additional traction This is a slower method but Stimson stated that it usually was effective and required no anesthesia

CHAPTER XXIX

HIP JOINT

On account of the strength of the hip joint with its deep ball-and-socket construction and heavy capsular ligaments dislocation is rare and occurs only with extreme violence The main types of dislocation at the hip are posterior and anterior posterior displacement being the more frequent Central dislocation of the hip is the result of penetration of the femoral head into the pelvis through a comminuted fracture of the acetabulum

Posterior dislocations at the hip joint. *Etiology* Posterior dislocation of the head of the femur is most often caused by an automobile accident, in which the occupant is thrown forward against the instrument panel or against the back of the front seat (dashboard dislocation) The severe thrusting force is transmitted backward from the flexed knee and may produce a fracture of the posterior lip of the acetabulum in addition to a rupture of the joint capsule permitting dislocation When the dislocation is caused by leverage the thigh is forcibly flexed adducted and inwardly rotated The Y ligament remains intact and acts as a fulcrum over which the head is levered as it ruptures the inferior and posterior portions of the capsule It is the tension of this ligament which keeps the thigh in the attitude of rigid flexion adduction and internal rotation The head of the femur rests upon the ilium above and behind the acetabulum

Examination The deformity is characteristic the hip being held in the fixed attitude In thin individuals the femoral head may be palpated lying displaced on the ilium although in most instances diagnosis is made only by the typical appearance and stereoscopic X ray examination The X ray films may show an associated fracture

Pressure of the displaced femoral head may cause damage to the sciatic nerve Aseptic necrosis of the head and traumatic arthritis may be late complications

Treatment The shock accompanying dislocations of the hip must be treated before attending to the local condition These dislocations are difficult to reduce because of the heavy musculature and the weight of the limb Never manipulate before an X ray examination has been made and do not attempt reduction without sufficient assistance Place the patient on the floor and manipulate under general or spinal anesthesia In reduction by the Allis method an assistant steadies the pelvis while the operator flexes the hip and simultaneously makes strong steady traction upward upon the thigh and then extends it

No jerky movements should be used Circumduction is not advisable, as this maneuver may injure the sciatic nerve

After reduction there is very little possibility of recurrence Use Russell's traction for four weeks and then permit gradual weight bearing with



FIG 311 ANTERIOR DISLOCATION AT THE HIP JOINT



FIG 311A FRACTURE DISLOCATION AT THE HIP

The posterior dislocation is accompanied by fracture of the head of the femur This injury produced permanent disability requiring an arthrodesis operation for relief of pain

the aid of crutches If there is an associated fracture of the rim of the acetabulum the traction should be continued for eight weeks or open reduction and internal fixation may be advisable

Anterior dislocations at the hip joint. *Etiology* Anterior dislocation



Fig 309 Posterior Dislocation at the Hip Joint



Fig 310 Manipulation for Dislocation at the Hip Joint

The patient is laid on the floor for the manipulation The operator removes his shoe and places his heel over the patient s groin The hip and knee are flexed at right angles With the pressure of the heel for counter traction and leverage upward traction upon the hip is made by the operator s grip on the flexed knee

CHAPTER XXX

KNEE JOINT

Dislocations of the patella In most instances dislocations of the patella are caused by direct violence Recurrent cases usually are seen in young women, in whom knock knee and relaxation of the joint capsule are predisposing causes The acute injury causes decided pain swelling and synovitis with loss of function The patella either is displaced partially and rests upon the external condyle of the femur, or it is displaced completely to the side of the condyle This displacement causes partial flexion of the knee with a decided prominence on the side of the joint and there is a palpable flattening between the condyles With the recurrent form of dislocation very little trauma is required for displacement, and the patella slips back between the condyles almost as readily as it slips out of place

Reduce the displacement by making lateral pressure on the patella as the hip is flexed and the knee is extended Treat the effusion in the joint by applying an ACF bandage over rubber sponges and later apply a circular plaster of Paris cast which should extend from the ankle to the groin (See Use of plaster of Paris page 59) Remove the plaster after six weeks and order a cage-brace for the knee This brace should be worn during athletics for the entire season Recurrent dislocations are curable by operation

Dislocations (fractures) of the semilunar cartilages Dislocation" of the semilunar cartilages is a misnomer the condition being in reality a tear or fracture This injury occurs most often in young adult males who engage in athletics and in those who work in crouched positions The internal meniscus is torn about ten times as often as the external meniscus The usual cause of this injury is a sudden rotation of the thigh on the leg while the knee is held in partial flexion and the foot is stationary Such a twist produces a grinding effect upon the cartilage with the result that it is torn and the broken portion is displaced and is caught outside of its normal position between the tibia and femur This displacement produces a characteristic locking' or blocking which causes a sickening form of pain and prevents complete extension of the knee This internal derangement of the joint produces a traumatic synovitis with an accumulation of fluid The torn portion of cartilage may slip back into its place spontaneously or it may remain displaced until reduced by manipulation The diagnosis is made by the typical history and localized tenderness to pressure over the joint margin the point of tenderness being usually one inch

of the head of the femur is produced by violent hyperabduction, which forces the greater trochanter against the rim of the acetabulum the Y ligament acts as a fulcrum and continuation of the force levers the head through a rent in the antero-inferior portion of the capsule to a position below and anterior to the acetabulum

Examination The patient is shocked The hip is held immovable in the typical attitude of abduction and external rotation with the knee flexed It is possible to flex the hip but extension and adduction are impossible X ray examination is necessary for corroboration of the provisional diagnosis stereoscopic films being especially valuable

Treatment Treat the shock before attempting reduction of the dislocation Place the patient on the floor using general or spinal anesthesia To reduce anterior dislocations the operator should remove his shoe and make upward traction on the flexed knee while pressing firmly against the femoral head with his heel At the same time the hip is rotated internally and then it is extended After reduction there is little tendency to recurrence and further treatment consists of bandaging the two ankles and knees together while the patient lies in bed for four weeks In older persons with a tendency to traumatic arthritis or if there is an associated fracture Russell s traction is advisable

For treatment of central dislocations (penetrating fractures of the acetabulum) see Fractures of the pelvic bones

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removal At the time of operation the entire joint should be inspected as it is not unusual to find a tear of both cartilages

Dislocations at the knee joint. The ligaments on all sides of the knee are so strong that complete dislocation is rare Partial displacement or subluxation may accompany severe sprains When dislocation does occur it is produced by extreme force applied anteriorly or posteriorly, which tears the crucial lateral and capsular ligaments Anterior dislocation is the more common and is caused by violent pressure or impact upon the extended knee This extreme violence may produce such serious damage to the popliteal structures as to require amputation The rupture of the ligaments often causes permanent weakness and limited motion

Reduce the dislocation immediately by making traction on the tibia combined with pressure and counter pressure to correct the displacement First immobilize the knee on a posterior splint watching for signs of circulatory and nerve damage Later apply a circular plaster of Paris dressing extending from the ankle to the groin (See Use of plaster of Paris page 59) This form of support should be worn for from three to six months depending upon the subsequent strength of the ligaments as determined when the plaster is changed every month Permit weight bearing after the third month but with the protection of plaster The use of a hinged cast or a hinged knee brace provides ambulatory support and graduated flexion movements during convalescence

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lateral to the patella. "Locking" occurs in about 75 per cent of cases Ordinary X ray films are of no help except to eliminate the possibility of minor fractures of the femur or tibia although X ray examination made after the knee is injected with air may be helpful in diagnosis

As the semilunar cartilages are avascular the fragments never unite unless the fracture occurs at their periphery where there is blood supply and consequently recurrent displacement is common Recurrent displacement of the cartilage in addition to the functional disability from the frequent unexpected blocking causes a chronic synovitis and weakness of the knee



Fig 312 Dislocation of the Knee

There is displacement in both planes This dislocation is reduced by direct pressure and then is immobilized in the extended position on a posterior plaster splint

Reduce dislocation of the internal semilunar cartilage under anesthesia by first flexing then abducting and externally rotating the knee finally internally rotate and extend the joint Reduction gives immediate relief from pain and permits full motion in the knee Treat displaced fractures of the external cartilage by adduction and internal rotation of the knee

Immobilize the knee in complete extension with a circular plaster of Paris cast which should extend from the ankle to the groin (See Use of plaster of Paris page 59) Permit walking during the six weeks the plaster is worn It is important to preserve the strength of the quadriceps muscle by appropriate exercises

Recurrent displacement of the cartilage can be relieved only by operative

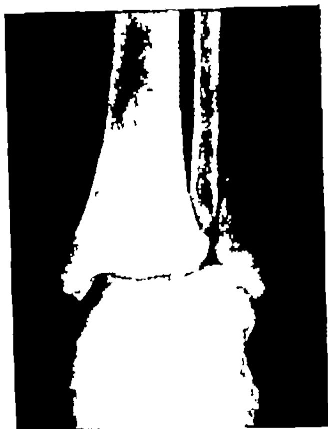


Fig 313 Fracture Dislocation at the Ankle
Note the disruption of the ankle mortise produced by the lateral dislocation



Fig 314 Fracture Dislocation at the Ankle
Posterior dislocation of the tibia with fracture of the fibula

CHAPTER XXXI

ANKLE AND FOOT

Dislocations at the ankle joint. Dislocations occur frequently as complications of fractures at the ankle (fracture-dislocations) Dislocations without accompanying fractures at this joint are unusual The dislocation usually is posterior and is caused by a sudden backward twist of the ankle the extreme plantarflexion tears the anterior capsular ligaments and usually also shears off the posterior articular surface of the tibia With posterior dislocation alone or associated with fracture there is a typical deformity which consists of an unusual prominence of the heel and a corresponding anterior depression below the tibia and drooping of the foot In a majority of instances X ray examination shows a severely disrupted joint with displacement of the foot to one side as well as backward with one or more associated fractures

A general anesthetic is usually necessary for complete relaxation To reduce posterior dislocation have an assistant hold the knee flexed to relax the muscle tension Draw the heel forward with one hand and at the same time press backward upon the tibia with the other hand Reduction is complete if the ankle can be dorsiflexed within a right angle

The T T Thomas method which is valuable for all severe fractures and dislocations about the ankle may be used if the above method fails The operator sits on the end of the table and removes his shoe By placing his heel in the patient s groin and grasping the foot with one hand and the ankle with the other hand very effective traction and countertraction combined with local pressure can be obtained

Immobilize the ankle at a right angle with a circular plaster of Paris dressing which should extend from the toes to the knee and bivalve the cast as soon as it has hardened (See Use of plaster of Paris page 59) It is important to check the position immediately by an X ray examination and to re-manipulate if necessary to secure complete reduction Failure to completely reduce these cases results in limited motion pain and subsequent disability which may require operation Remove the plaster after two weeks when most of the swelling will have subsided and apply a fresh cast which should be worn for from four to six weeks before permitting the patient to walk (See Follow up treatment under fractures of the ankle)

Complete reduction by manipulation alone may be impossible and operative fixation of the fragment may be necessary An alternate method

Compound dislocations and fracture-dislocations require an immediate debridement operation, following which the ankle should be immobilized at a right angle in a molded plaster of Paris splint (See Chapter III)



FIG 316a TARSAL DISLOCATION
Dislocation at the subastragalar joint



FIG 316b TARSAL DISLOCATION
Same case as in preceding film after reduction by manual traction combined with lateral pressure

Dislocations of the astragalus. The astragalus may be dislocated by violent plantarflexion of the foot the displacement usually being anterior Such extreme violence may produce a compound dislocation at the ankle with extensive damage to the soft structures There is marked swelling and the displaced astragalus forms a decided projection on the dorsum of

consists of making traction on the os calcis with a Steinmann pin while plaster of Paris is applied the pin being left imbedded in the plaster for six weeks

Anterior dislocations of the ankle are rare and seldom occur without fractures (fracture-dislocation) When violent force produces anterior displacement of the foot on the leg the astragalus usually carries with it a triangular piece of the anterior articular surface of the tibia There is a typical deformity the normal prominence of the heel being absent, and there is a corresponding prominence of the astragalus on the anterior sur

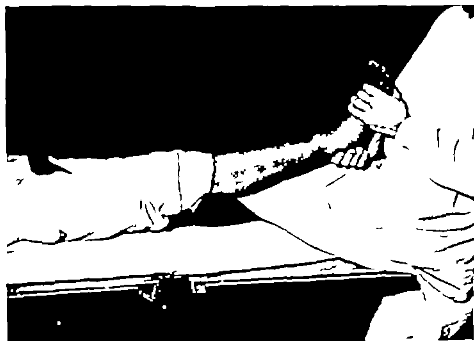


Fig 315 T T Thomas Method

This is useful for traction during manipulation for fractures and dislocations at the ankle The surgeon stands at the end of the table removing his shoe and placing his heel in the patient s groin for counter traction

face of the ankle This dislocation may be reduced by plantarflexing the ankle as backward pressure is made on the foot but when there is an associated fracture *it usually is necessary to perform an operation for internal* fixation of the fragments

Lateral dislocations of the ankle joint are caused by complete rupture of the lateral ligaments there may not be an accompanying fracture Watson-Jones has shown that such a dislocation can be demonstrated plainly by holding the foot sharply abducted or adducted as the anteroposterior X ray film is exposed This condition should be treated by immobilization in plaster of Paris for eight weeks

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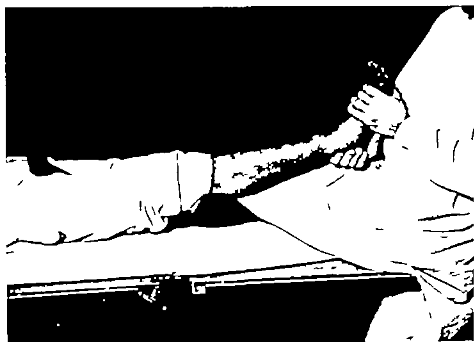


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the foot with alteration in the other bony points about the ankle. Reduce anterior dislocation of the astragalus by making firm pressure upon the displaced bone while pressing the foot into extreme plantarflexion and then dorsiflex the ankle to a right angle. Open reduction is indicated when the astragalus cannot be replaced by manipulation. Immobilize the



FIG 318 DISLOCATION AT THE TARSO-METATARSAL JOINT
This was reduced by pressure but prolonged fixation in plaster of Paris was necessary to control tendency to re-dislocation

ankle at a right angle with circular plaster, and bivalve the plaster as soon as it has hardened as a precaution on account of the probability of decided swelling (See Use of plaster of Paris page 50.) Remove the plaster after eight weeks and give follow up treatment as for fractures of the ankle.

Dislocations at the subastragalar (astragalo-calcaneal) joint are uncommon; they are caused by a severe twisting injury. Reduction by traction



FIG 317 MIDTARSAL DISLOCATION

There is a complete dislocation at the astragaloscaphoid joint The second film shows complete reduction, which was accomplished by traction and leverage over a sandbag combined with direct pressure

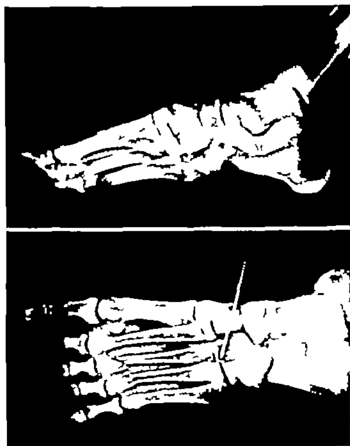


FIG 317A DISLOCATION OF INTERNAL CUNEIFORM BONE

The first film shows dorsal and mesial displacement The second film shows the dislocated bone replaced by manipulation and held by a Kirschner wire The wire was drilled through the skin through the replaced bone and then into the adjacent bone No immobilization was necessary Note accompanying fractures of the metatarsal bones

which should extend from the toes to the knee (See Use of plaster of Paris page 59.) The ankle should be maintained at a right angle, with the foot neither inverted nor everted. Cut the plaster on both sides as soon as it has hardened as a precaution against circulatory trouble from the accompanying damage to the soft parts. Order an X ray examination as a check on reduction. After eight weeks remove the plaster and give the same follow up treatment as for fractures of the foot. Operation is necessary if the displacement cannot be reduced or if there is subsequent pain from traumatic arthritis. Chronic subluxation and pain require an arthrodesis operation.

Dislocations at the metatarsophalangeal and interphalangeal joints. These dislocations are not common as severe injury usually causes a fracture of the toes. They seldom occur while a shoe is worn. Dislocation at the metatarsophalangeal joint of the great toe is the most common and is produced indirectly by stubbing or directly by severe wrenching; extreme violence sometimes causes a compound dislocation. With dislocation of the toes the displacement is similar to that with dislocation of the thumb and fingers, the distal bone being dorsal. There is a characteristic deformity, edema and a lack of normal mobility. X ray examination may show an accompanying fracture.

To reduce these dislocations lever the distal bone over the proximal bone by making direct pressure combined with hyperextension. Immobilize the toe with a wooden tongue blade for two weeks and then advise contrast foot baths.

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combined with pressure is usually effective The foot should be immobilized with plaster of Paris for eight weeks, and then follow up treatment is given as for fractures of the ankle.

Dislocations at the midtarsal and tarsometatarsal joints. Dislocations at these joints without fractures are unusual Dislocations and fracture-



FIG 319 DISLOCATION AT METATARSOPHALANGEAL JOINT OF FOURTH TOE
This was reduced by traction hyperextension and pressure



FIG 320 DISLOCATION AT END OF GREAT TOE
There is dorsal displacement of the phalanx, the displacement being similar to that of a dislocation of a finger This was reduced by hyperextension combined with local pressure

dislocations often are multiple being caused by heavy objects falling upon the foot or by severe wrenching The displacement may not be palpable on account of the extreme swelling and hemorrhage from damage to the soft structures, and accurate diagnosis can be made only by X ray examination

Manipulate the foot under general anesthesia, applying traction combined with pressure, and immobilize with a circular plaster of Paris dressing

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